Iron and Steel Engineer

Established 1907 as Proceedings of A. I. & S. E. E.

J. F. KELLY, Editor

CONTENTS

Volume VI. May, 1929 Number V.

Tentative Program—Annual Convention and Exposition II

Editorial—
Association of Iron and Steel Electrical Engineers Conventions and Expositions III

Recent Improvements at Gulf States Steel Company—By W. B. Connally, Chief Electrician, Gulf States Steel Company, Alabama City, Ala..... 177

Discussion—Presented by Brent Wiley and E. S. Lammers..... 184

Furnace Bindings—By A. R. Tegge, Asst. Chief Engineer, Lukens Steel Company, Coatesville, Pa..... 185

Discussion—Presented by H. C. Siebert, C. S. Proudfoot and W. T. Kennedy... 190

Utilization of Fuel in Great Britain—By T. A. Peebles, Engineering Vice President, Hagan Corporation, Pittsburgh, Pa. 191

The Application of the Corduroy Crane to Industrial Plants—By N. P. Farrar, Asst. Sales Mgr., Harnischfeger Corp., Milwaukee, Wisconsin 192

Fuel Utilization Practiced in Europe—By Martin J. Conway, Fuel Engineer, Lukens Steel Company, Coatesville, Pa.... 194

Material Handling Using Gasoline Locomotives—By George D. Whitcomb, Pres., Geo. D. Whitcomb Co., Rochelle, Ill. 197

One Hundred Days Without an Accident—By R. F. Gale, Plant Engineer, Midvale Company, Philadelphia, Pa..... 201

Discussion—Presented by Martin J. Conway and George W. Pfeffer..... 204

Junior Division of the A. I. & S. E. E.—Steel Mill Lighting, Part 2..... 206

Items of Interest—Review of Papers to be presented before British Iron and Steel Institute 209

(List of Advertisers IV)

Published Monthly by

Association of Iron and Steel Electrical Engineers

BOARD OF DIRECTORS—1928-1929

C. S. PROUDFOOT, President, Vanadium Corp. of America, Niagara Falls, N. Y.

F. W. CRAMER, 1st Vice Pres.—Republic Iron & Steel Company, Youngstown, Ohio.
R. M. HUSSEY, 2nd Vice Pres.—Jones & Laughlin Steel Corporation, Aliquippa, Pa.
JAMES FARRINGTON, Treasurer—Wheeling Steel Corp., Steubenville, Ohio.
A. A. STEWART, Secretary—Pittsburgh Steel Company, Monessen, Pa.
A. J. STANDING, Past President—Bethlehem Steel Company, Bethlehem, Pa.
S. S. WALES, Past President—Carnegie Steel Co., Pittsburgh, Pa.
KARL L. LANDGREBE, Director at Large—Tennessee Coal, Iron & R. R. Co., Ensley, Ala.
M. J. CONWAY, Director—Lukens Steel Company, Coatesville, Pa.
E. F. BLANK, Director—Jones & Laughlin Steel Corp., Pittsburgh, Pa.
I. N. TULL, Director—Corrigan McKinney Steel Co., Cleveland, Ohio.
E. L. UPP, Director—National Tube Company, Gary, Ind.
J. E. SAYER, Director—Tennessee Coal, Iron & R. R. Co., Ensley, Ala.
P. T. VANDERWAART, Director—New Jersey Zinc Company, Palmerton, Pa.

E. FRIEDLAENDER, Honorary Director—Pittsburgh, Pa.

JOHN F. KELLY, Managing Director—Empire Building, Pittsburgh, Pa.

Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.
Subscription Price $5.00 per Year. Single Copy 50c

Tentative Program

Convention and Iron and Steel Exposition

Auspices

Association of Iron and Steel Electrical Engineers

June 17th, 18th, 19th, 20th, 21st, 1929

William Penn Hotel **Pittsburgh, Pa.**

MONDAY, JUNE 17th

9:00 A. M.—Registration—Main Lobby, Wm. Penn Hotel.
9:30 A. M.—Business Session. Membership Invited.

Electrical Engineering Division

10:00 A. M.—"Electrical Welding," by Electric Welding Committee, Mr. S. S. Wales, Chairman.
11:00 A. M.—"The Use of Moving Pictures to Illustrate the Generation of Involute Gearing and the Use of Moving Pictures and Polarized Light as a Method of Studying Gear Stresses," by Mr. W. H. Himes and Mr. R. V. Baud.
12:30 P. M.—Informal Luncheon. Members, Guests and Exhibitors.

Safety Engineering Division

2:00 P. M.—"The Incorporation of Safety Into Electric Station Design," by Mr. V. R. Bacon.
7:00 P. M.—Official Opening of the Iron and Steel Exposition. Main Lobby, Wm. Penn Hotel.
9:00 P. M.—Informal Reception. Members, Guests and Exhibitors. Mezzanine Floor, Wm. Penn Hotel.

TUESDAY, JUNE 18th

All Engineering Divisions

8:30 A. M.—A. I. & S. E. E. Breakfast. Members, Exhibitors and Guests. Wm. Penn Hotel.

Electrical Engineering Division

9:30 A. M.—"Anti-Friction Bearings for Mill Type Motors," by Special Committee on Bearings. Mr. F. D. Egan, Chairman.
11:00 A. M.—"Electric Heating," by Electric Heat Committee. Mr. Geo. H. Schaeffer, Chairman.
11:45 A. M.—"Electrical Developments in the Iron and Steel Industry," by Electric Development Committee. Mr. Walter H. Burr, Chairman.

Combustion Engineering Division

9:30 A. M.—"Utilization of Steam," by Mr. L. C. Edgar.
10:00 A. M.—"Feed Water Treatment," by Mr. S. E. Hall.
11:15 A. M.—"Efficiency Versus Economy," by Mr. H. G. Ebdon.

WEDNESDAY, JUNE 19th

Electrical Engineering Division

10:00 A. M.—"Electric Departmental Organization," by Shop Practices Committee. Mr. J. J. Booth, Chairman.
10:45 A. M.—"The Selection of Electric Drives," by Mr. L. A. Umansky.

Combustion Engineering Division

10:00 A. M.—"The Utilization of Waste Gases," by Mr. Walter Flanagan.
10:30 A. M.—"Liquid Fuel," by Mr. R. C. Vroom.
11:15 A. M."—Economizers," by Mr. Walter Keenan.

THURSDAY, JUNE 20th

Electrical Engineering Division

10:00 A. M.—"Portable Electric Tools," by Portable Electric Tool Committee. Mr. J. S. Murray, Chairman.
10:30 A. M.—"Some Methods of Best Utilizing Electrification in the Steel Industry," by Mr. G. E. Stoltz.

Combustion Engineering Division

10:00 A. M.—"Gas Producers," by Mr. Frank E. Leahy.
10:30 A. M.—"The Application of Pulverized Fuel in Industrial Furnaces," by Mr. W. O. Renkin.

THURSDAY AFTERNOON, JUNE 20th

2:00 P. M.—All Engineering Divisions, Guests and Exhibitors Inspection Trip to the Jones and Laughlin Steel Corporation at Aliquippa. Special Train Leaves P. & L. E. Railroad, Southside. Tickets on Train.
9:30 P. M.—Formal Reception. Members, Guests and Exhibitors. Special Entertaining Features.

FRIDAY, JUNE 21st

10:00 A. M.—"A Lighting Survey of Steel Plant," by Mr. S. G. Hibben.
10:45 A. M.—"Time Current Control for DC Motors," by D. C. Wright.

IRON AND STEEL EXPOSITION

Monday—Opens at 1:30 P. M., Closes at 9:30 P. M.
Tuesday—Opens at 1:30 P. M., Closes at 9:30 P. M.
Wednesday—Opens at 1:30 P. M., Closes at 9:30 P. M.
Thursday—Opens at 9:30 A. M., Closes 12:30 P. M., Opens 7:00 P. M., Closes 9:00 P. M.
Friday—Opens 1:30 P. M., Closes 9:30 P. M.
Friday Evening—Maintenance Department Employees Evening.
Refer to the June Issue of the Iron and Steel Engineer for Complete and Official Program.

Teck. 50

EDITORIAL

Association of Iron and Steel Electrical Engineers Conventions and Expositions

In 1907, twenty-eight Engineers met in Convention, to witness at a large electrical manufacturing plant, the progress that was being made, in apparatus used in Steel Mills. Out of this Exposition grew a Society of Engineers, whose achievements are recorded in the 20 years progress in the Iron and Steel Industry.

In 1929, thousands of Engineers, Executives, Mechanics will assemble in Convention to deliberate with the questions that contribute to progress in Industry and to witness once again the developments in the apparatus used to process and to produce the 50,000,000 tons of Steel per year.

Conventions and Expositions are colleges of learning where men, who plan, who toil, give up freely their experiences and their opinions, founded on results secured in the field of operation, at the top of the Skip Hoist; at the mouth of the Casting Hole; at the door of the blazing Open Hearth; at the pouring spout of the ladle of molten liquid; at the crushing, grinding mills which roll and pound into shape the rails, the pipe, the plates, the sheets, the strips, the beams, the nails, the needles, the pins and the tacks used in our domestic life.

Progress and developments in Industry, are founded largely upon experiences, not necessarily our own, but the sum total of ours and our neighbors, experiences as a rule are discussed, disseminated, in personal contact—through conversation, many times man to man, often in technical sessions, through visits, plant to plant but mostly at Conventions where men meet, east, west, north and south.

In relating experiences, diversity of opinion, often prevails, new channels are opened up, new phases presented. Herein lies the real value of Conventions and Expositions.

For illustration—A subject is presented—values, results, experiences are discussed in connection with a particular phase of processing or producing steel, immediately a difference of opinion arises, often influenced by geographical location, with the result that what perhaps is a proper application for one plant is not exactly suited for another. All of this information brought to the surface, cannot help but be of value to the Engineer, the Executive and the Mechanic in his every day problems.

Sometimes the proper value is not attached to the Expositions of Apparatus which represents the progress in the various steel mill arts.

The Expositions afford both the manufacturer and the user an opportunity to meet on a common ground to exchange, first hand opinions, relative to the apparatus directly in question, many times the manufacturer is able to demonstrate by actual operation, exactly what class of service the apparatus will meet. Differences of opinion are thus ironed out. An experience of this nature at our 1926 Chicago Exposition has helped to develop a particular type of heavy duty crane service which is at the present time operating satisfactorily in many of our large steel plants.

Another fair question in connection with Expositions is, what opportunity has any operating man to witness, to examine, to actually come in contact with the number of new developments in the various steel mill arts, that are presented at the Expositions; also where may the manufacturers meet the same number of users in so short a space of time?

The 1929 Convention and Exposition being held in June at Pittsburgh will be the greatest event of the year in Iron and Steel circles. Subjects for discussion have been selected with a view of presenting the recent developments in steel mill practices—Four Branches of Engineering will receive the major attention, Electrical, Combustion, Mechanical, Safety.

The Program, the Papers to be presented, before the Technical Sessions of the Convention, a complete story of the Inspection trip to one of the large steel mills in the Pittsburgh district, lists of exhibitors, will all be included in the June Convention issue of the Iron and Steel Engineer.

INDEX TO ADVERTISERS

A

Alliance Machine Company 253
Allis Chalmers Mfg. Company 273
American Gas Association 232
American Heat Economy Bureau 222
Appleton Electric Company 269

B

Bartlett Hayward Company 275
Blaw Knox Company 218
E. W. Bliss Company 221
Bristol Company 265
Bull Dog Electric Products Company 266

C

Chapman Stein Company 237
Clark Controller Company 247
Cleveland Crane & Engineering Company 280
Colts Patent Fire Arms Mfg. Co. 274
Combustion Engineering Corp. 211–267
Crocker Wheeler Electric Mfg. Co. 220
Crouse Hinds Company 227
Cutler Hammer, Inc. 213–239–271–285

D

DeLaval Steam Turbine Company 253–254
Delta Star Electric Co. 254
M. H. Detrick Company 288
Doubleday Hill Electric Company 255

E

Economy Fuse & Mfg. Company 286
Electric Controller & Mfg. Company 219–225
Electrical Engineers Equipment Co 256
Electric Machinery Mfg. Co. 268
Electric Power Equipment Corp. 238
Electro Dynamic Company 282
Erie Malleable Iron Company 240

F

Farrel Birmingham Company, Inc. 212
Franklin Electric & Construction Co. 258
Freyn Engineering Co. 240A-241A

G

General Electric Company Cover–4–279
Gears & Forgings, Inc. 264
Graybar Electric Company 248

H

Harnischfeger Corp. 236
Holophane Company 214
Hyatt Roller Bearing Company 229

I

Ideal Commutator Dresser Company 257
International Nickel Company 228
International Combustion Engrg. Corp. 211–267
Iron City Electric Company 252
ITE Circuit Breaker Company ..... Cover– 3

J

Jefferson Electric Company 272
Johns Manville Corporation 281

K

Keystone Lubricating Company ..... Cover– 1

L

Lapp Insulator Company, Inc. 230
Le Carbone Company 278

M

Martindale Electric Company 243
Moloney Electric Company 252
Monitor Controller Company 262
Morgan Construction Company 224
Morgan Engineering Company 216
Morganite Brush Company 250

N

National Air Filter Company 246
National Carbon Company 231
Nichols Lintern Company 233
New Departure Mfg. Company 223
Norma Hoffmann Bearings Corp. 245

O

Ohio Electric & Controller Company 234

P

B. F. Perkins & Sons, Inc. 249
Pyle-National Company 244

R

Railway & Industrial Engineering Co. 277
Reed Air Filter Company 287
Reliance Electric & Engineering Company 276
Rockbestos Products Corp. 283
Roller Smith Company 242
Rowan Controller Company 250

S

Shepard Niles Crane & Hoist Corp. 270
SKF Industries, Inc. 235
Smith & Serrell 256
Stackpole Carbon Company 260
Standard Underground Cable Company 263

T

Thompson Electric Company 251
Timken Roller Bearing Company 217
Tool Steel Gear & Pinion Company 255
Trico Fuse Mfg. Company 259

U

United States Graphite Company 257
R. E. Uptegraff Mfg. Co. 251

V

V.V. Fittings Company 284

W

Westinghouse Elec. & Mfg. Co. Cover 2–215–249–261
Weston Electrical Instrument Corp. 248
George D. Whitcomb Co. 226
Edwin L. Wiegand Company 241

Recent Improvements at Gulf States Steel Co. †

By W. B. CONNALLY*

These improvements comprise the electrification of our Garrett rod mill and the erection of a new power house, and embody the latest and most advanced engineering practice. Improvements are best appraised in comparison with the old, and for this reason a brief review of the past will be interesting.

Figure 1 shows the original layout of the rod mill. The roughing stands, 1 to 6 inclusive, were direct connected to a 1500 H.P., 64 R.P.M., tandem compound steam engine. The intermediate stands 7 to 16 inclusive, were rope driven from a 5000 H.P., 84 R.P.M. cross compound engine. This is a group drive from the engine rope drum to four separate mill shafts, which numbered consecutively, drive the following stands:

No. 1. . . . . Stands 8, 9 and 10.
No. 2. . . . . Stands 11 and 12.
No. 3. . . . . Stands 13 and 14.
No. 4. . . . . Stands 15 and 16.

Stand No. 7 was rope connected from the driven shaft of Stands 8, 9 and 10. The Finishing stands 17 and 18 were rope driven from a third engine, 1400 H.P., 110 R.P.M. cross compound, located on the opposite side of the Mill. The reel drive was belt connected to the finishing stands, and in this respect after the manner of No. 7 stand.

Auxiliary power was obtained from 1—1200 KW., 2—250 KW., and 2—450 KW. direct current engine driven generators. The first two groups of machines were located at the rod mill and the latter at the present site of the power house. Later these generators at the rod mill were replaced with 3—750 KW. motor generator sets, and power purchased for this purpose.

Following this, 2—2000 KW., 2200 volt, 3 phase, 60 cycle low pressure turbo-generators were installed to make use of the exhaust steam from the rod mill engines. With this electric power available, the purchased power for the motor generator sets was, for the time being, discontinued. However, this tie-in was again resumed with the subsequent installation of the bar mill.

†Presented before Birmingham District Section, A. I. & S. E. E., January 26, 1929.

*Chief Electrician, Gulf States Steel Co., Alabama City, Ala.

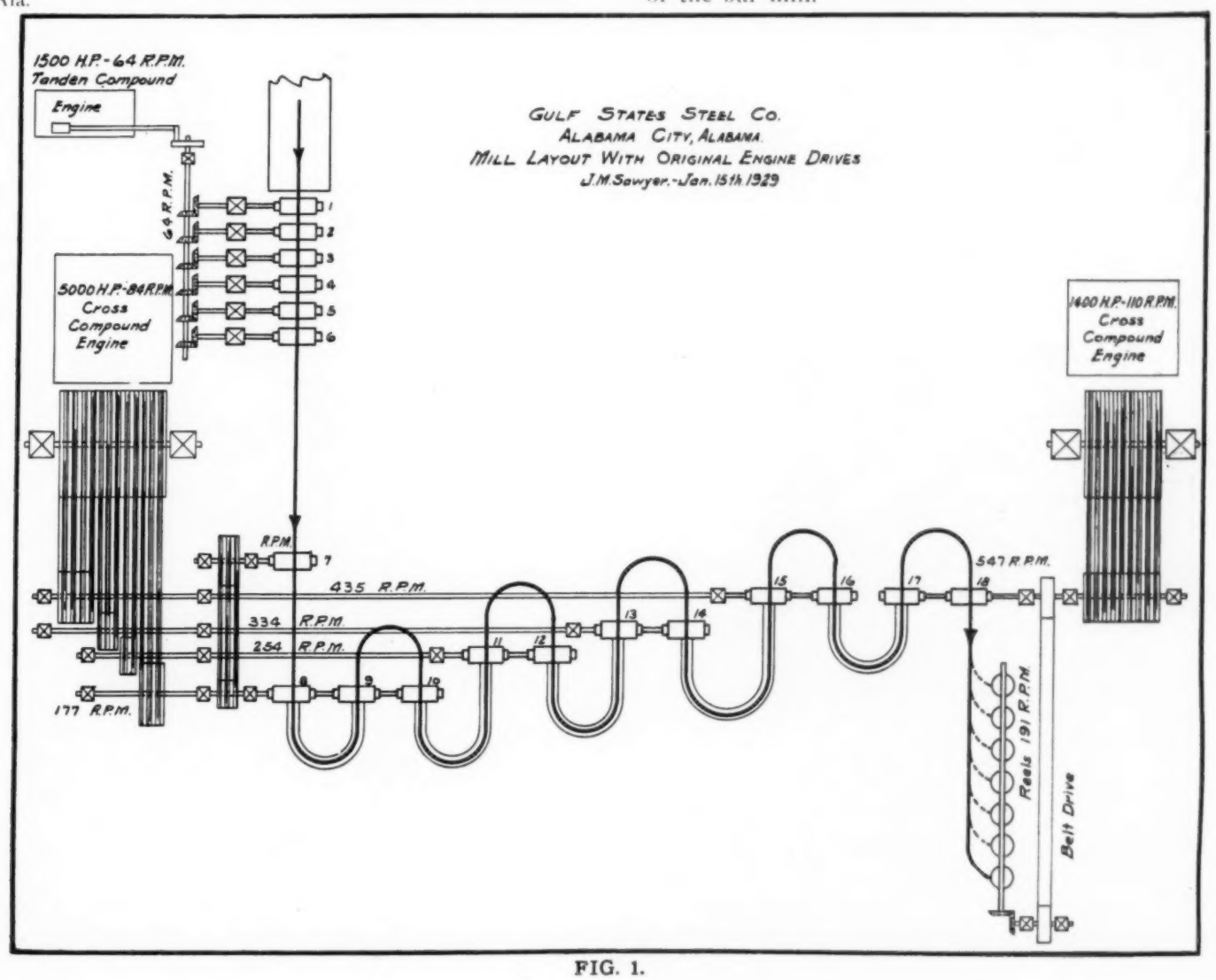


FIG. 1.

The rod mill boiler plant is still in-tact and consists of 22 Sterling type boilers, 150 lbs. gauge. Eight of these are hand fired, 375 boiler H.P. each; six are stoker fired, 375 boiler H.P. each and the remaining eight are 500 boiler H.P. each, stoker fired. Three of the 375 H.P. boilers are equipped with By-Product gas for auxiliary fuel. With the electrification of the rod mill, the blooming mill is the only remaining steam drive, including the auxiliary hydraulic pumps. The eight larger boiler units fulfill these requirements.

This brings us up to the present improvements. The new rod mill motor layout is shown in Figure 2 and you will note that the mill stands are essentially as before. The three engines have been replaced with six main drive motors and one reel motor. With reference to the main drives, three are gear reduction units and three are direct connected. The table on Figure 2 gives the detailed horse powers and speeds. The largest single unit is 2750 H.P. and drives two adjacent mill shafts through a double gear unit.

The feature of this mill is not in the motor layout, but rather that synchronous motors are used for these drives, with the exception of the finishing stands, and reel, which are direct current motors. During the past few years considerable knowledge has been gained in the design of high starting torque synchronous motors and this has greatly enlarged the uses of this type of motor. This, together with the high efficiency and admirable power factor characteristics, brought about the adoption of this motor

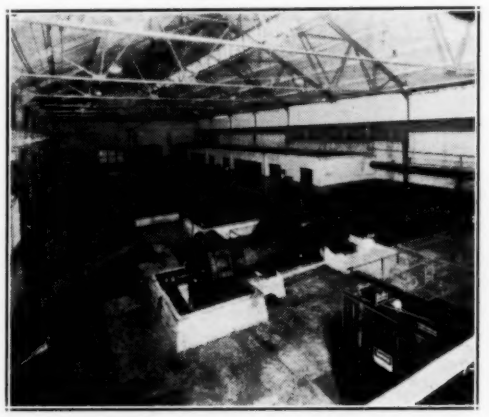


FIG. 3.

for this mill, which I understand is the first application of synchronous motors to a Garrett mill.

These synchronous motors are designed to give 100% starting torque, 50% pull in, 225% pull out,

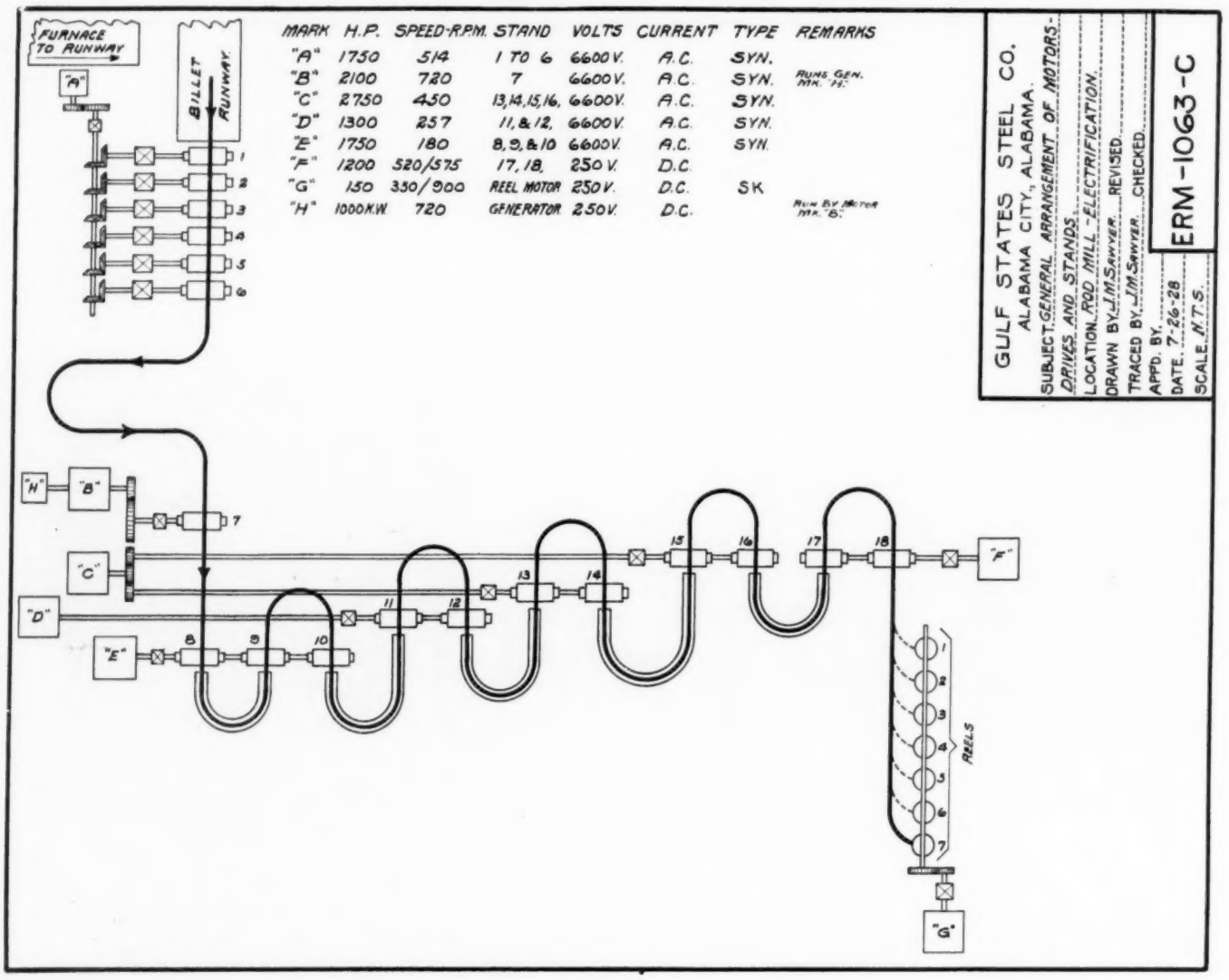

MARK H.P. SPEED-R.P.M. STAND VOLTS CURRENT TYPE REMARKS
"A" 1750 514 1 TO 6 6600 V. A.C. SYN.
"B" 2100 720 7 6600 V. A.C. SYN. RUNS GEN. MK. "H".
"C" 2750 450 13,14,15,16, 6600 V. A.C. SYN.
"D" 1300 257 11, & 12, 6600 V. A.C. SYN.
"E" 1750 180 8, 9, & 10 6600 V. A.C. SYN.
"F" 1200 520/575 17, 18, 250 V. D.C.
"G" 150 330/900 REEL MOTOR 250 V. D.C. SK
"H" 1000 K.W. 720 GENERATOR 250 V. D.C. RUN BY MOTOR MK. "B".
FURNACE TO RUNWAY
BILLET RUNWAY
REELS
GULF STATES STEEL CO.
ALABAMA CITY, ALABAMA.
SUBJECT. GENERAL ARRANGEMENT OF MOTORS-DRIVES AND STANDS.
LOCATION. ROD MILL - ELECTRIFICATION.
DRAWN BY. J.M. SAWYER. REVISED
TRACED BY. J.M. SAWYER. CHECKED
APPD. BY.
DATE. 7-26-28
SCALE. N.T.S.
ERM-1063-C

FIG. 2.

and 375% current inrush on full voltage starting. The motor fields are designed to give 90% leading power factor at full load. Three of these motors, including the bedplates, are of a welded fabricated construction.

A west view of the motor room photographed from the crane cab is shown in Fig. 3. The roughing motor is in the remote right hand corner. Fig. 4 is the east view of this motor room and shows the control in the back ground. The 1200 H.P. direct current finishing motor is located on the opposite side of the mill and is shown in Fig. 5. A close up

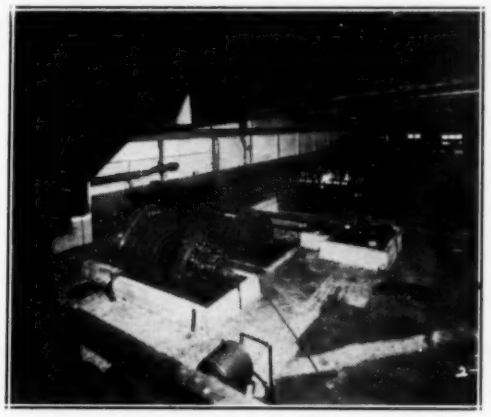


FIG. 4.

view of the roughing motor and gear unit is given in Fig. 6. All of this equipment, including control and switching, was installed within thirty days. Before erection could begin the old steam engines had to be dismantled and the two low pressure turbines removed and new foundations poured. Nevertheless the mill was back into production fifteen days ahead of schedule.

For speed adjustment, the finishing and reel motors are direct current. An A.C. adjustable speed set was at first considered for the 1200 H.P. finishing motor, but for simplicity direct current was ulti-

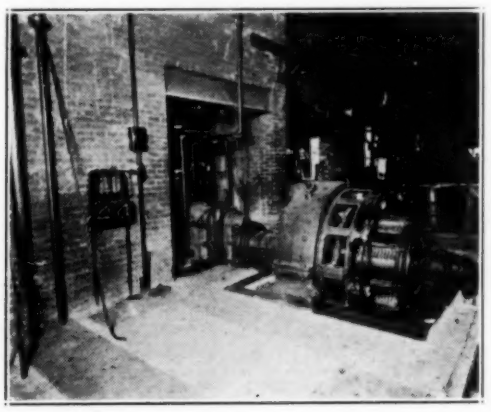


FIG. 5.

mately adopted. By a unique arrangement, direct current power for this motor is obtained from a 1000 KW 250 volt generator direct connected to the synchronous motor driving stand No. 7. This being a single stand, well adapted itself to this arrangement. This generator operates at constant voltage, 250 volt, and in addition supplies power to the reel motor and all excitation for the synchronous motors. A close up view of the 2100 H.P. No. 7 stand motor and direct connected 1000 KW generator is shown in Fig. 7.

No elaborate control is required for starting the 1200 H.P. direct current finishing motor. This motor is simply started by gradually building up the generator voltage, which is accomplished by means of a potentiometer rheostat in the generator field. This rheostat is motor operated and controlled from a control switch on the generator panel. The control circuits are arranged so that this rheostat must be in the initial position before the armature circuit breaker can be closed. A rheostat in the motor field provides speed adjustment.

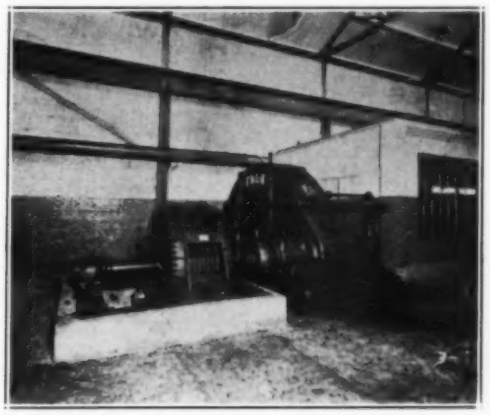


FIG. 6.

The reel motor can be operated either from this 1000 KW generator or from the 250 volt shop circuit. Thus this motor can be operated independent of the mill, which is convenient for trial or test purposes. This motor is started by armature resistance and the control interlocked with the finishing motor, so that stopping of the reel motor from any cause, will also stop the finishing motor.

The control for the main motors is built into one switchboard as shown in Fig. 8. There are five starting panels, one generator panel and one direct current feeder panel. On the latter a double throw

FIG. 7.

back of board knife switch, makes it possible to change the synchronous motor excitation from the shop circuit to the generator on No. 7 stand, and vice versa. It is usual not to transfer this exciting current to the generator until after all the motors are accelerated and on the line. In this way the motors can be started independent of the No. 7 stand motor. A duplicate switch also provides this

same change in source of power to the reel motor as previously mentioned.

The control is very simple as you probably noted from the photograph of the starting panels (Fig. 8). This simplicity is further exemplified in Fig. 9, which gives a schematic of the wiring to the motors. All of the synchronous motors are started across the line with the exception of the largest motor, 2750 H.P., which uses reduced voltage starting. Reduced voltage is obtained by means of an air core reactor and with this method the running breaker can be

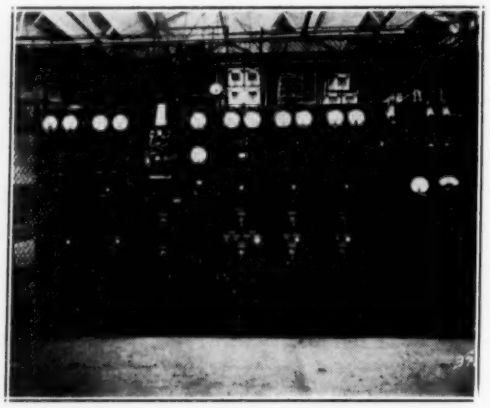


FIG. 8.

closed without first opening the starting breaker, permitting closed transition, a desirable feature for a motor of this size.

Power to the motor bus is supplied at 6600 volt, 3 phase, 60 cycle from a single feeder from the rod mill sub-station located at the further end of the motor room. This feeder breaker is interlocked with

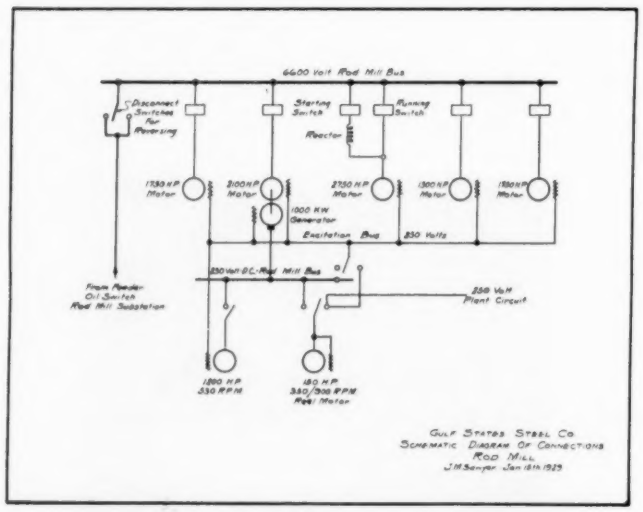


FIG. 9.

the control so that it cannot be closed unless all of the motor breakers are open. On the other hand the opening of the feeder breaker from any cause will trip all of the motor breakers. In addition a single push button is provided on the control switchboard for opening the feeder breaker in emergency. There is a similar push button located at the finishing stands.

The feeder from the rod mill sub-station is connected to the motor bus through a set of double throw disconnect switches, so that the motors can be reversed in emergency for backing out a cobble, should this occasion arise. The feeder at the rod mill sub-station bus can be supplied from two sources of power; namely, Alabama Power lines or from our own power house. This adequately safeguards the continuity of service at this mill. Certain features of the tie-in with the Alabama Power are more fully described later on.

The synchronous motor line—starters have some features of interest. Overload on any motor lights a red indicating lamp on the respective starting panel and sounds an alarm. Each motor is provided with a **field protective relay** so that the loss of any motor field will trip the feeder breaker and stop the entire mill. Field failure protection can only be operative after the motors are fully accelerated, and pulled into step. The control especially provides for this wherein field failure protection is inserted on the closing of the field contactor and after a definite time delay, required to cover the pull in period of the motor.

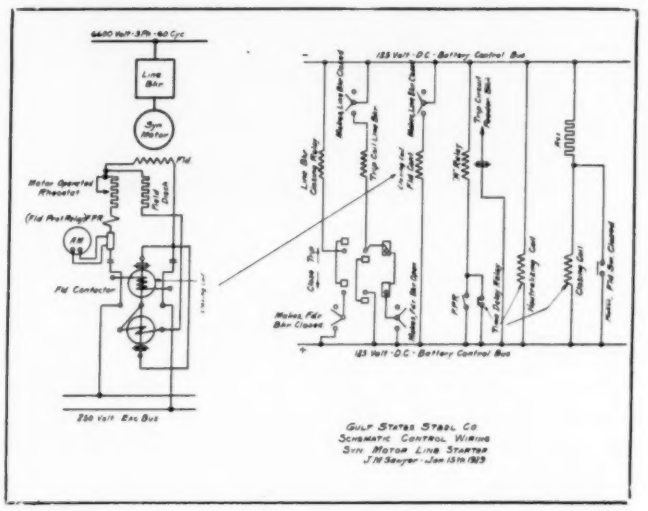


FIG. 10.

Figure 10 shows a schematic of the control wiring on one of the synchronous motor line starters. The line breaker is closed from a control switch on the switchboard after which acceleration is full automatic. The motor field circuit is not closed until synchronism is approximately reached and this is determined automatically by the field contactor itself. Because of this inherent characteristic, the field contactor is spoken of as a field frequency contactor.

This is a double magnet contactor with two up contacts closed from the top magnet and one down contact, gravity closed, and held sealed by the bottom magnet. The top magnet is direct current and the lower magnet alternating current. The lower magnet coil is in series with the motor field through the discharge circuit and maintains the lower contact closed, and in so doing keeps the discharge circuit established during the starting period of the motor. With the lower contact held closed, the top contacts, by means of which the field is excited, are held open. The top magnet coil is energized from the control circuit on the closing of the line breaker, but the induced field discharge current is also established at this instant, and accordingly with the lower magnet coil energized from this induced current, the top magnet has insufficient pull to close the contactor and energize the field.

At stand still the induced field current and the

induced voltage in the field winding is at maximum frequency and maximum voltage. As the motor picks up in speed this frequency decreases, and likewise the voltage. Therefore, as these two variables decrease proportionately, the induced field current remains practically constant until synchronism is approximately reached, that is 95% speed. At this point the induced field current suddenly drops to a very low value, and the top magnet then over-powers, thereby closing the contactor and applying excitation to the motor field.

When the field contactor closes, the bottom contact opens before the top contacts close. Consequently a small auxiliary spring closed carbon to copper, contact is placed at the top of the contactor between the two main poles, and functions to open just as the main contacts close. This auxiliary contact parallels the bottom contact and in this manner the discharge circuit is not actually opened until after excitation is applied to the motor fields.

The auxiliary relay "A" is the trip relay for the feeder breaker, primarily operative from the field protective relay. This is a normally closed relay; that is, the contact is closed in the de-energized position of the relay. Normally the relay coil is energized and the trip contact held open. After the motor is fully accelerated the circuit to this relay coil is through the field protective relay only, but previous to this, the field protective relay contact is paralleled by an inductive time delay relay. On the closing of the field contactor, the inductive time delay relay opens at a predetermined time, making the field failure relay operative. You will note from the diagram that the field protective relay coil is energized immediately on the closing of the field contactor, but between the closing of this contactor and the actual pulling in step of the motor, the field current is transitory, and for this reason a time delay is injected into the above operation to give time for the field circuit to become stable.

The inductive time delay relay is in itself somewhat novel. This is a single magnet relay with a double coil, one neutralizing, and the other closing. The neutralizing coil has just sufficient turns to neutralize the residual magnetism. In this way the relay armature can seal tight against the pole faces

MOTOR DRIVEN GARRETT ROD MILL
TYPICAL TONNAGE RECORD
ROLLING No. 5 ROD

Date	Gross Tons	K.W. Hours	K.W. Hours Per Ton
1-1-29	345	68,000	197
1-2-29	314	62,000	198
1-3-29	319	63,000	198
*1-4-29	386	65,000	169
1-5-29	325	61,000	188
1-7-29	334	65,000	195
1-8-29	373	70,000	188
1-9-29	350	71,000	203
1-10-29	351	69,000	197
1-11-29	348	71,000	204
1-12-29	306	56,000	183
1-13-29	343	70,000	204
1-14-29	331	67,000	202
1-15-29	342	66,000	193

Average for the above, 197 k. w. hours per ton.
*Mixed tonnage.

Gulf States Steel Co.
J. M. S.—Jan. 15th, 1929

FIG. 11.

of the magnet, without the use of an air gap, or non-magnetic spacers, to prevent freezing. Thus the inductance of the relay is relatively high, and an appreciable time delay can be obtained when the relay is de-energized by the shunting of the closing coil, which is accomplished by an auxiliary contact on the field contactor.

The third segment on the control switch, (see Fig. 10), establishes a trip circuit from the feeder breaker so that should it open each motor breaker will be opened as previously mentioned. The control circuits are supplied from a 125 volt battery, which is a positive and reliable source. The motor fields are adjustable for power factor correction by means of a motor operated rheostat. Each motor has duplicate control except the large 2750 H.P.

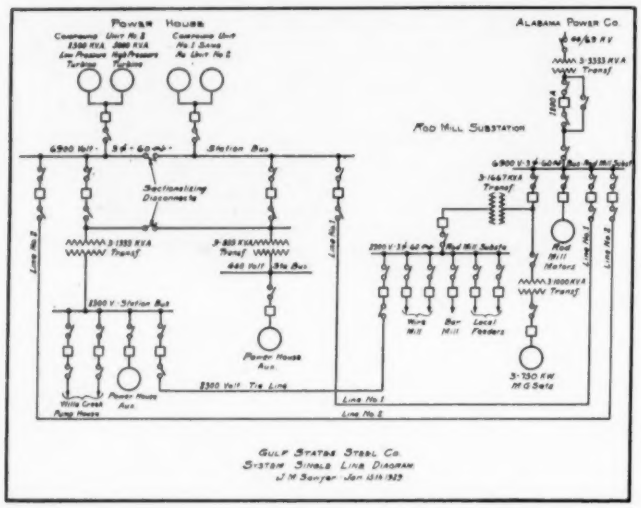


FIG. 12.

motor which has reactance starting and time limit acceleration. The time limit acceleration is obtained from a small auxiliary motor-operated contact drum. However, the essential functions of this starter is otherwise similar to the line-starters. The inductive time delay relay described in the preceding paragraph is omitted from this panel, as this necessary time delay is incorporated in the timing drum.

The operations of the new drives have been very

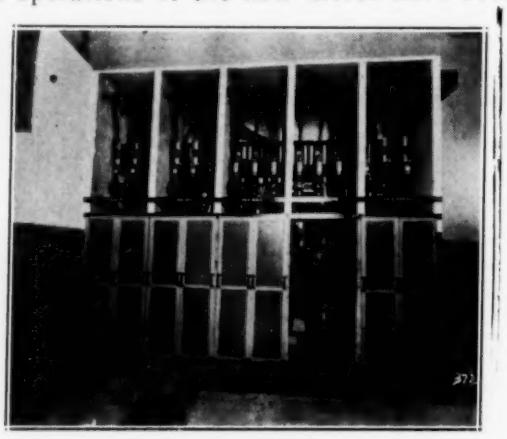


FIG. 13.

successful and satisfactory in all details. As a matter of interest, I have picked at random a two weeks' production on this mill, and have tabulated the tonnages in Fig. No. 11 with the corresponding power consumption. With one exception, all of this production was on No. 5 rods and the power requirements vary from 183 to 204 kilowatt hours per ton. The average for the two weeks' production on this size rod was 197 kilowatt hours per ton. Only the power for the main motors and the reel motor is included in these figures.

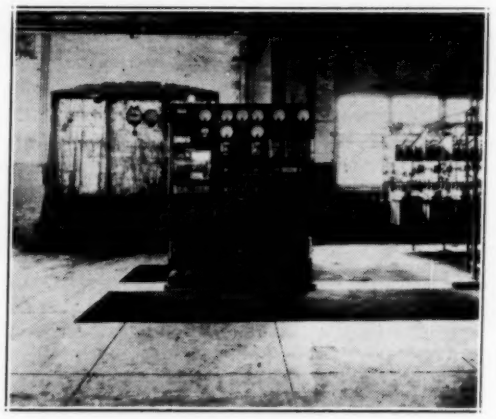


FIG. 14.

Prior to this electrification, this mill, engine driven, held the production record for all Garrett rod mills on the rolling of No. 5 rods; namely, 362 gross tons, twelve hour run. The new motor drives have been operating regularly since the first of September, and in the early part of December, a gross twelve hour production of 384 tons, No. 5 rods was rolled exceeding the previous all time record.

This mill rolls from 4"x4" billets. We are contemplating an automatic signaling device wherein these billets will be released with precision regularity, depending on the size rod being rolled. We propose to accomplish this by means of a motor operated timing drum, with a single set of contacts,

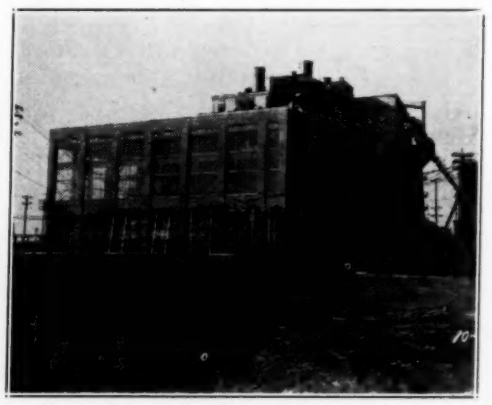


FIG. 15.

which will energize a single stroke alarm bell, on each revolution of the contact drum. A small adjustable speed direct current motor will be used for driving this contact drum through suitable gearing. By means of a small field rheostat the Head Roller can vary the signals from 2.88 to 5.76 per minute, which is a range of 173 to 345 billets per hour. A speed indicator calibrated in rolling terms will give visible indication of the timing.

As mentioned in the foregoing, our power system is tied in with Alabama Power. A one line diagram of the main power lines is shown in Fig.

No. 12. Alabama Power is delivered at 44,000 volts, 3 phase, 60 cycle and stepped down to 6600 volts through a bank of 3—3333 KVA Transformers, for connection to the rod mill sub-station bus. Figure No. 13 gives a photograph of this bus and the switching arrangement. The switching at this point makes it possible to isolate Alabama Power or connect it

FIG. 16.

with either of the two power lines from the power house, as it may be desired. This switching is controlled from the switchboard shown in Fig. No. 14. Further reference to the one line diagram will reveal the other plant loads which are self-explanatory. The effect of the tie-in with Alabama Power makes it possible for the power house to operate at its capacity, with power demands exceeding this capacity drawn from the outside source.

High tension lines No. 1 and No. 2 connecting the rod mill sub-station and the power house are approximately one mile long. These lines can be op-

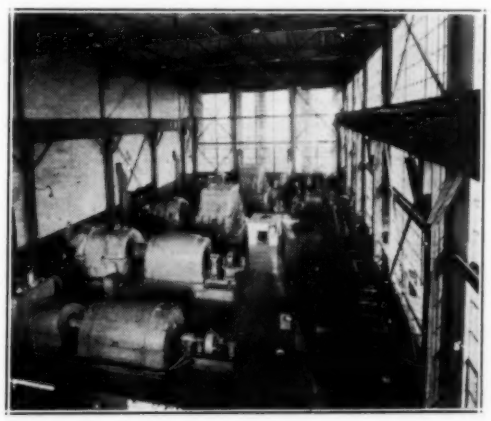


FIG. 17.

erated either singly or in parallel, and are protected so that a short circuit on either line is isolated without interrupting service, when these lines are operated in parallel. An exterior view of the new power house is shown in Fig. No. 15, with the high lines in the fore-ground.

Generation at the power house consists of 2—5000 KVA high pressure turbines and 2—2500 KVA low pressure turbines, the latter having been moved from the rod mill and rewound for 6600 volts. Refer to Figs. No. 16 and No. 17 for views of the turbine room floor. The high pressure turbine is the first unit in Fig. 17 The next machine is the low pressure turbine. You will note that the former is smaller in overall dimensions, but twice the size of the latter in capacity. The two machines in the back ground are turbo blowers.

The low pressure turbo-generators are permanently connected electrically to their respective high pressure units, and in starting up, excitation is first applied to both generators so that both the high pressure and low pressure units will be brought up to speed together. The low pressure turbine has no governor control other than an over speed device which shuts down the high pressure unit. The low pressure turbine receives all of the steam from the

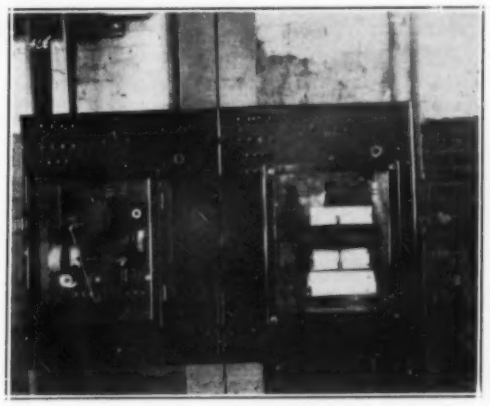


FIG. 18.

high pressure turbine and governor control is entirely on the high pressure unit. There are two of these compound generating units, making a total of 15000 KVA.

Refer again to the one line diagram in Fig. 12 and note that each of these compound units is connected to one half of the main 6600 volt station bus which can be sectionalized by means of a disconnecting switch in between. This, together with the disconnecting switch in the cross connection between the two banks of transformers, makes it possible to shut down either half of the main 6600 volt bus for repairs or maintenance work.

There is also the 2300 volt tie-in to the rod mill sub-station which adds to the flexibility of the switch-

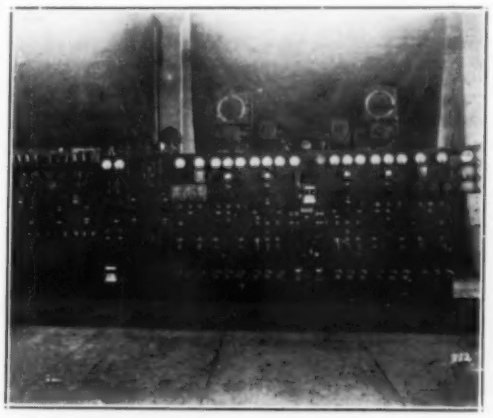


FIG. 19.

ing arrangement. This line was already in place, and put to advantageous use in this way. This connection gives two sources of 2300 volt power, both to the power house and to the rod mill sub-station.

Synchronizing with Alabama Power can be done either at the power house or at the rod mill sub-station, which ever desired. The rod mill synchro-

noscope is paralleled by a similar instrument at the power house switchboard so that the power house attendant can adjust the turbine governors to bring the two systems into step if this is necessary. The rod mill operator waits until the two systems come together and closes the breaker. Under certain conditions the lines can be closed at the rod mill sub-station and left open at the power house, where the power house operator would do the synchronizing. Sometimes the two systems operate very close together, and synchronizing is simply a case of waiting for the two systems to come gradually together, without the need of any governor adjustment.

In connection with power generated and power received, we have a special metering arrangement that is worth mentioning. Alabama Power is metered at the rod mill sub-station, where we have a graphic recording watt meter and a current balance Transmitter. Fig. 18 shows a photograph of these two instruments. By means of the Transmitter, this metering is sent to the power house over a pair of wires to a receiving instrument. The receiving instrument located at the power house is fundamentally a recording milli-ammeter. The graphic A.C. Wattmeter has an attachment whereby a balance is set up between the milli-amperes transmitted and the power metered. Hence the transmitter is a small motor operated rheostat which will seek a position, that will bring about this current balance.

There is a similar arrangement at the power house wherein a totalizing graphic wattmeter measures all the power generated and this metering with current balance attachment and duplicate transmitter is delivered not to a remote point as in the other case, but only a few feet away to the same receiving instrument. In this manner the receiving instrument graphically records the total power generated and the power purchased. These instruments can be seen in Fig. No. 19, which is a photograph of the power house switchboard. The upper meter to the right is the totalizing graphic watt meter. Just below this meter is the Transmitter. A few panels to the left and near the bottom, is the totalizing receiving meter.

The difference between the reading of the receiving instrument and the Power House graphic watt meter is the amount received from Alabama Power. When these two readings are the same, it either means that no power is being received from Alabama Power or else Alabama Power is receiving rather than delivering power. The graphic instruments are not designed to read backwards, which accounts for the latter. It was not intended that the graphic instruments would record the interchange of power between the two systems, as integrating watthour meters were provided for this purpose.

The new power plant, as a whole, has many distinctive features. These include the use of 400 lbs. steam pressure with superheat to a total steam temperature of 700° F., complete return of condensate to boilers, through use of surface condensers; use of evaporators for production of lower pressure steam for uses outside the station; distilled water make-up; electric drive for all auxiliaries and interstage bleeding of all prime movers for heating of boiler feed water to a temperature approaching 350° F. Other features now more common in steel plant design, particularly in the boiler house, include high settings; air-cooled walls; combination firing of furnace gas and pulverized coal; air pre-heaters; complete automatic control of combustion, and sluice system for removal of boiler refuse.

The major portion of fuel used is obtained from an adjacent 500 ton blast furnace. Pulverized fuel is supplied as an auxiliary to carry a part of the load and to act during periods when gas supply is momentarily curtailed. Four 900 h.p. Sterling boilers are installed.

DISCUSSION

Brent Wiley*: I am very much pleased to have this opportunity to meet with the Birmingham Section of the Association of Iron and Steel Electrical Engineers for, though I have visited Birmingham a number of times in the last several years, this is the first chance that I have had to attend one of your meetings.

The paper presented by Mr. Connally deals largely with one very important subject, namely, economy, which undoubtedly is one of the guiding factors in practically all of the leading questions of the times, both from a business and political standpoint.

I recently heard a talk by Mr. David Lawrence, President of the U. S. Daily Publishing Co. and of the United Press Association, Washington, D. C., on the subject of "The Trend of the Times." In this talk he stated that a careful study and solution of problems of economy would do more to make general progress than any other single subject, and that the results obtained from concentration on this point would be of far reaching consequence.

Mr. Connally's paper is an excellent example of the trend of the times in reference to improved ideas in regard to the subject of electric drive in steel mills. The paper emphasizes the advancement which has been made in synchronous motor design and fitness for steel mill requirements.

The generation of electric power as described in Mr. Connally's paper also presents some very interesting phases of economic generation and the power plant is a splendid example of low cost power production in which advantage is taken of the very low cost of fuel supply.

During my visit to Birmingham I had the opportunity to visit several other plants besides the Gulf States Steel Co. at Alabama City, Ala., and was particularly impressed with my visit to the Fairfield Works of the Tennessee Coal, Iron & R. R., where I saw a very up-to-date power generating plant using blast furnace gas from two modern type blast furnaces. I understand that power is generated in this plant at exceptionally low cost.

E. S. Lammers*: Mr. Connally has been a strong advocate of synchronous motors for a number of years and the use of these motors on this rod mill is, to a large measure, the termination of an ideal that he entertained even before the recent developments in high starting torque synchronous motors made such an application possible.

For example, when the wire mill was electrified, as Mr. Connally mentioned in his introductory re-

---

*Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

**General Engineer, Westinghouse Elec. & Mfg. Co., Atlanta, Ga.

marks, he requested synchronous motors for the wire blocks, but manufacturers, at that time, were unwilling to quote on this type of motor and wound rotor induction motor were consequently installed. In view of this, I would like to say that three—400 H.P. synchronous motors were included in these improvements at Gulf States Steel for replacing three direct current motors on the wire blocks.

A synchronous motor, inherently, has the fundamental principles for high starting torques, after the order of a double rotor Squirrel Cage motor; namely, a damping ring which gives low reactance and high resistance, and a field winding which gives high reactance and low resistance. It is the proper balance of these factors, combined with proper starting resistance in the field windings, that makes high starting torque, high pull-in torques, and high torque efficiencies possible.

*Furnace Bindings**

By A. R. TEGGE†

Much has been published concerning fuels, refractories, furnace practice, etc. Furnace lines and masonry construction are widely discussed. Naturally we would expect considerable literature concerning the details of the furnace bindings. Unfortunately this is not the case. If we exclude certain water cooled details we can say with safety that practically nothing has been published concerning this detail of furnace construction.

Of course we can say that the binding of a furnace is a secondary matter. This, no doubt, is true. The purpose of a furnace is to make it possible to utilize the combustion of fuels in metallurgical operations, that is, say for our purposes, to melt or heat steel. It follows that the fuels are of primary importance. Since we cannot use the fuels without a masonry structure to confine and direct the products of combustion, therefore the problem of combustion reverts, we may say, to a problem of masonry.

However, our masonry structure would not be possible without a skeleton of steel or furnace binding for its support. In the case of Open Hearth furnaces the weight of this binding exceeds two tons per ton capacity of the furnace. The cost of this structural skeleton therefore is quite an item in the first cost of a furnace. Faulty design of the binding is reflected in masonry failure. For instance, improper support for the skew backs will, if not corrected, bring premature failure of a furnace roof. The efficiency of the binding is reflected in the furnace maintenance costs.

While the first cost of the furnace binding is quite an item, yet the depreciation factor should be low. If properly designed and installed in the first place, the skeleton of a furnace will be used, as a whole, for an indefinite number of rebuilds.

Considering the furnace binding in the light of first cost, maintenance costs, depreciation and influence on life of the masonry the problem of proper design assumes greater importance than usually given to it. It becomes something more than just another job for a detailer in the drawing room.

As there is such a vast difference in the duties or requirements of the steel plant furnaces, a discussion of the binding can only be of a general nature. The purpose of this paper is to outline a few general principles rather than go into a elaborate description of the binding of one particular furnace.

Assuming that the masonry outline is fixed, the rational design of the furnace binding demands that we consider the various factors entering into the binding problems. We may outline as follows:

(a) Foundation.
(b) Support for masonry.
(c) Support for auxiliaries such as furnace doors, door hoists, burners, etc.
(d) Temperature and temperature changes.
(e) Stresses produced by masonry and stresses produced by temperature changes.
(f) Mechanical and chemical injury to masonry and binding.
(g) Materials of construction.

Further analysis reduces items a, b, c, d and e of the above outline to determination of the dead

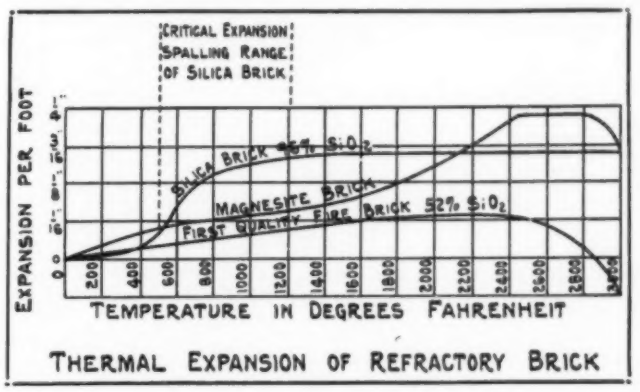


FIG. 1.

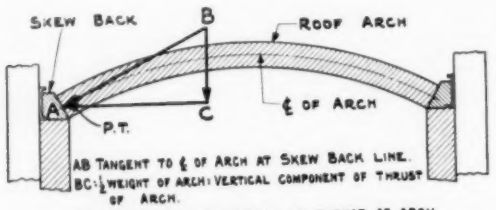
load and live load stresses and stresses due to changes of temperatures. The live load stresses are few, principally those caused by door hoists and similar apparatus and should cause us no trouble. The dead load stresses with the exception of those due to arches are easily determined. An approximate value for the thrust of an arch can be obtained graphically by considering the vertical reaction or ½ weight of the arch as being the vertical component of the thrust whose line of action is tangent to the center line of the arch at the skew back line (See figure 2). The suspended roof will eliminate one of our major arch forces. However, we must not forget the thrusts due to arches in the flues, ports, etc.

Unfortunately our stress calculations are rendered

*Presented before Mid-Winter Conference, Combustion Engineering Division, A. I. & S. E. E., at Pittsburgh, Pa., January 23rd, 1929.

†Asst. Chief Engr., Lukens Steel Co., Coatesville, Pa.

practically valueless by the influence of the temperature changes in the masonry. This is illustrated by the action of the arch under temperature changes. Under an increase in temperature the arch will rise,



THRUST OF ARCH
FIG. 2

changing not only the magnitude but the line of action of the arch thrust. The softening of the brick under high temperature will not only modify the shape of the arch but will also completely change the location of the line of action of the forces within the arch. Any attempt to calculate the forces acting will only be pure guesswork.

The influence of thermal expansion of the masonry is not only confined to arches but obviously takes place throughout the furnace. We may note the expansion of the hearth of a furnace.

ROLLED STEEL SECTIONS FOR BUCKSTAYS.

SECTION	WIDTH OF FLANGE IN.	THICKNESS OF WEB IN.	SECTION MODULUS IN.³	COST FACTOR: WEIGHT PER FOOT × COST PER LB. / SECTION MODULUS
100# A.R.A.-SER.B RAIL @ 33.33# (NEW)	5.141	0.563	13.70	$\frac{33.33 \times 2.25}{13.70} = 5.47$
" " " " @ 29.00# (SCRAP)	5.141	0.563	10.50	$\frac{29.00 \times 0.75}{10.50} = 2.07$
9" I @ 21.8#	4.33	0.290	18.87	$\frac{21.8 \times 2.20}{18.87} = 2.55$
9" BETH. B @ 20.5#	5.50	0.250	19.22	$\frac{20.5 \times 2.30}{19.22} = 2.45$
12" I @ 31.8#	5.00	0.350	35.97	$\frac{31.8 \times 2.20}{35.97} = 1.95$
12" BETH. B @ 28.0#	6.50	0.245	35.60	$\frac{28.0 \times 2.30}{35.60} = 1.81$
12" × 3" SLAB @ 122.40#	3.00	3.00	72.00	$\frac{122.40 \times 2.25}{72} = 3.82$
15" I @ 42.9#	5.50	0.410	58.91	$\frac{42.9 \times 2.20}{58.91} = 1.60$
15" BETH. B @ 38.5#	6.75	0.290	59.68	$\frac{38.5 \times 2.30}{59.68} = 1.48$
15" × 5" SLAB @ 255.0#	5.00	5.00	187.50	$\frac{255.0 \times 2.25}{187.50} = 3.06$
18" I @ 54.7#	6.00	0.460	88.39	$\frac{54.7 \times 2.20}{88.39} = 1.36$
18" BETH. B @ 49.0#	7.50	0.330	89.20	$\frac{49.0 \times 2.40}{89.20} = 1.32$
18" × 5" SLAB @ 306.0#	5.00	5.00	270.00	$\frac{306.0 \times 2.25}{270} = 2.55$

FIG. 3

We have reliable information concerning the expansion of refractories under temperature changes (See Fig. 1.) Also the crushing strength of refractories at high temperatures is known. However, we know very little or nothing of the relation of stress to strain at high temperatures. Not knowing this, it will be impossible to predict the thrust due to expansion when refractories are restrained from expanding. This led to an early use of adjustable tie rods, springs and other provisions for expansion, of which more later.

Referring again to Fig. 1 we note that silica brick at 2000°F expands nearly 3/16" per foot. Now, steel at 700°F expands less than 1/16" per ft. Bearing in mind that steel as furnace binding should not exceed in temperature 700°F and that our masonry will as a rule average 2000°F there is a difference in expansion of ⅛" per foot to be accounted for. To subject certain members of the furnace binding, such as tie rods, to a strain of ⅛" per foot to compensate for the thermal expansion of the masonry is of course unthinkable.

Other provisions for expansion must be made. Fortunately this difference of thermal expansion is minimized by our practice in masonry construction and furnace operation. In operating, the furnace, when once brought up to temperature, will be maintained at temperature ranges where no change in the dimensions (expansion or contraction) of the masonry occurs. Examination of Fig. 1 will show that over a wide range in temperature no expansion (or contraction) will take place. With the exception of the smaller heating furnaces, steel plant furnaces will only be shut down entirely when major repairs are necessary. The mason can provide for the expansion of the masonry by the introduction of expansion joints, laying brick with open joints where permissible, etc. Provisions in the furnace binding for expansion and contraction therefore does not appear to be necessary, neither is the continual adjusting of tie rod nuts.

MATERIALS OF CONSTRUCTION

Modern practice has given us no new materials for furnace bindings but rather has enabled us to use these materials to better advantage. We may mention water cooling, insulation, arc and gas welding and cutting and the suspended roof as influencing our practice in furnace binding. The use of heat resisting alloy steels is not justified on account of the high cost of this material. However, for details of continuous furnaces (skids or rollers) this material may be necessary. A brief study of the qualities of the materials of construction given below may be in order.

Concrete:
(Plain (without reinforcement).
(Reinforced.
(Insulating concrete.
Cast Iron:
Cast Steel
Rolled Steel:
(Railroad rails (new and scrap).
(Shapes.
(Slabs.
(Plates.

Concrete: Concrete without reinforcement need not be discussed to any extent. We will find its use restricted to mass application such as foundation piers. Occasionally it is used as mats under checker chambers.

Reinforced concrete admits of many applications. Properly protected by insulating materials it is being used to replace steel binding in the underground or below floor level sections of certain furnaces, such as pit furnaces.

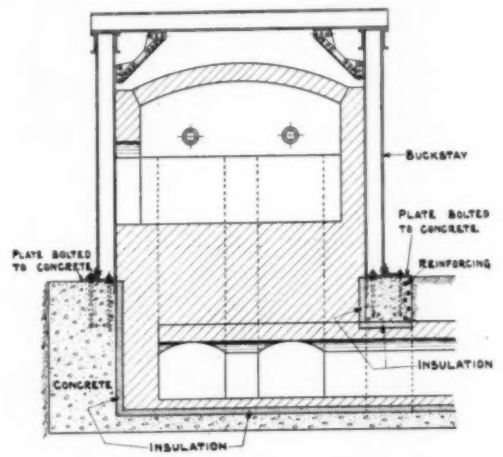
The disintegration of concrete begins at the low temperature of 500°F. The use of limestone in the aggregate is another contributing factor to the failure of concrete in furnace work. Therefore investigate the temperature gradient before using concrete on furnace work.

The use of insulating concretes such as Sil-O-Cel C-3 concrete offers great possibilities. The crushing strength is high, thus overcoming objections in this respect in other insulating materials. The temperature gradient must be investigated.

Cast Iron: Cast Iron compared with steel (cast

or rolled) is very weak in tension and bending. However, under the action of high temperatures it resists warping and oxidation to a remarkable degree. Therefore it is an excellent material for door jambs, sills, air cooled chills and furnace hearth pans. As it is quite easy to make a casting with a wrought iron or steel pipe 'cast in," such a casting makes an ideal water cooled furnace detail. We may call attention to the "growth" of cast iron under the influence of high temperature. This is ordinarily of no consequence but may in isolated instances lead to trouble.

Cast Steel: This material is practically obsolete as binding material. It is expensive and does not possess the virtues of cast iron in respect to oxidization and warping under high temperatures. Furthermore, unless a foundry is accessible there is always a delay of several weeks in obtaining castings. However, on account of its strength it can be used where cast iron would be useless, for instance, in members under bending stresses. Water cooled buckstays of cast steel are a good illustration.



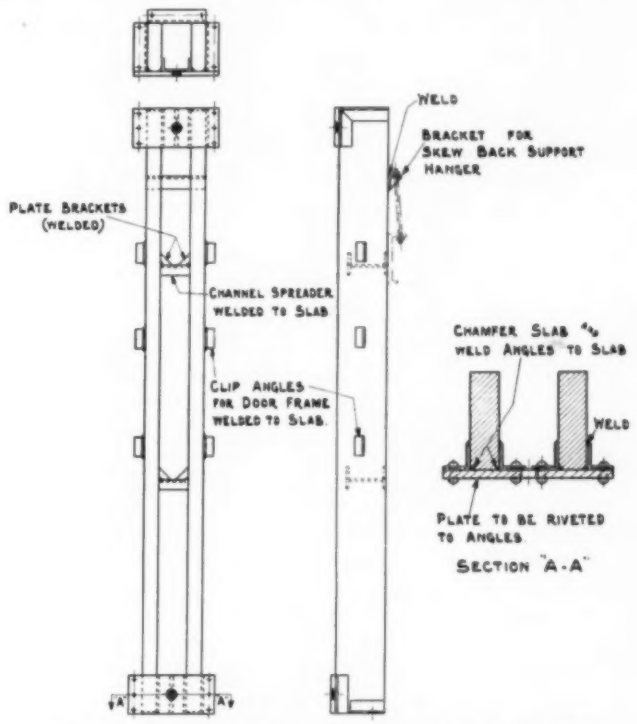
SECTION THROUGH HEATING FURNACE
FIG. 4

Rolled Steel: As rolled steel is by far the most economical material for use as furnace binding material we may well afford to spend some time considering the various sections available. As most of the members of the furnace binding are subject to bending stresses it would seem plausible that a section designed primarily for economy in resisting bending stresses would be the ideal section to use, that is a section where the ratio, section modulus to area (S/A), is greatest. This would lead us to choose the newer sections such as the Bethlehem B and G. These sections have wider flanges than the standard I beam section which in the case of buckstays directly against hearth walls may be a detriment. Upon examination you will find that hearth buckstays frequently fail due to overheating of the flanges in contact with the furnace walls. The web also is thinner in the newer sections causing premature buckling failures when subjected to heat.

Fig. 3 has been prepared showing elements of a few sections. Attention is called to the last column headed cost factor which will give means of comparing the values of sections on a cost basis when considering bending only.

Railroad rails have been extensively used in the past. The old mill man today will get a piece of scrap rail to "brace her" when something busts. This is not surprising for steel rails were the first "shape" rolled, and scrap rails in fair condition are certainly in evidence at all Open Hearth scrap piles. New rails are not economical as binding material as Fig. 3 will show. The difficulty of making connections is another limiting factor. The low cost of scrap rails would warrant their use (See Fig. 3 showing data on 100 lbs A. R. A. Ser. B rail with head worn down ½"). On account of the uncertain condition of scrap rails it is not advisable to use them as important members. For supports for hearths of heating furnaces they are entirely satisfactory.

Steel slabs either rolled as slabs or gas cut from heavy plates are no doubt the best material for use as hearth buckstays on Open Hearth furnaces. These buckstays receive more punishment than any other members of the furnace binding. In addition to resisting the thrust of the roof arches they are subjected to the intense heat of the furnace walls, the knocks and jars of the charging machines and the corona of flame at the doors. As buckstays for sloping back walls on Open Hearths slabs have no competition. There is, however, the question of making proper connections. Drilling slabs for angle connections is a rather expensive proposition. The slab buckstay shown on Fig. 5 was made up by welding connecting angles to the slab.

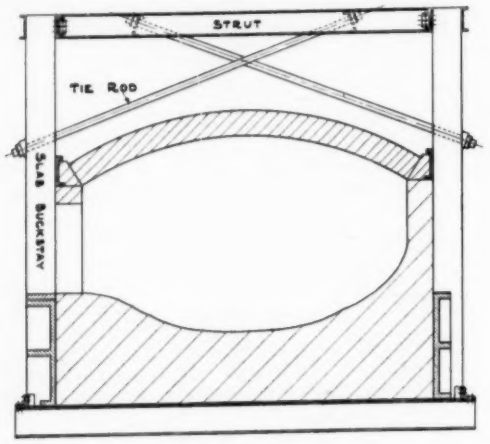


SLAB BUCKSTAY WITH WELDED CONNECTION ANGLES.
FIG. 5

It may be well before leaving the subject of rolled steel sections to call attention to such sections used to resist bending. Good structural steel practice requires that the ratio length of member to width of flange (L/B) shall not exceed 40 if the member is not supported laterally. (See Steel Construction, A. I. S. C. p. 163). Furthermore, the web of rolled sections must be stiffened, if necessary. These are two points often overlooked. It may be argued that

the furnace walls will offer lateral support, but when we consider that these walls also transmit heat to the binding thus weakening the flange in contact with the masonry, the lateral support of the furnace walls is questionable.

Plates: Any lengthy discussion of plates as furnace binding material seems superfluous. They find their main sphere as material for the construction of water cooled details. In fact, our modern water cooled furnace would be an impossibility without the welded plate.



A RIGID BINDING
FIG. 6

Having disposed of the materials of construction a few words as to structural details are in order.

Drainage: Most furnaces have a section below the ground level. These may be regenerator chambers, flues, slag pockets or in the case of some pit furnaces practically the entire furnace. If the subsoil does not drain naturally, provisions must be made for artificial drainage. This can often be accomplished by drainage sumps and sump pumps. The sumps must extend at least 4 feet below the lowest level of the furnace, and the sumps equipped with pumps controlled by floats. The water level must not reach the furnace. Steel caissons or pans have been using but they are effective for a short time only. Rust and opening of seams soon permit the infiltration of water.

Concrete: Piers should be proportioned on the carrying capacity of the soil. Where a concrete mat is used, as under the regenerator chambers, this mat or slab should be reinforced. A layer of insulating concrete should be placed over this slab before laying the fire brick floor of the regenerator chambers and flues.

Binding: The binding proper should be independent of all furnace masonry. It should be self-supporting, that is, it should not depend on the masonry to hold it in place. It should be possible to erect the steel work complete before any masonry is started. This practice will come in to advantage in the case of a complete rebuild.

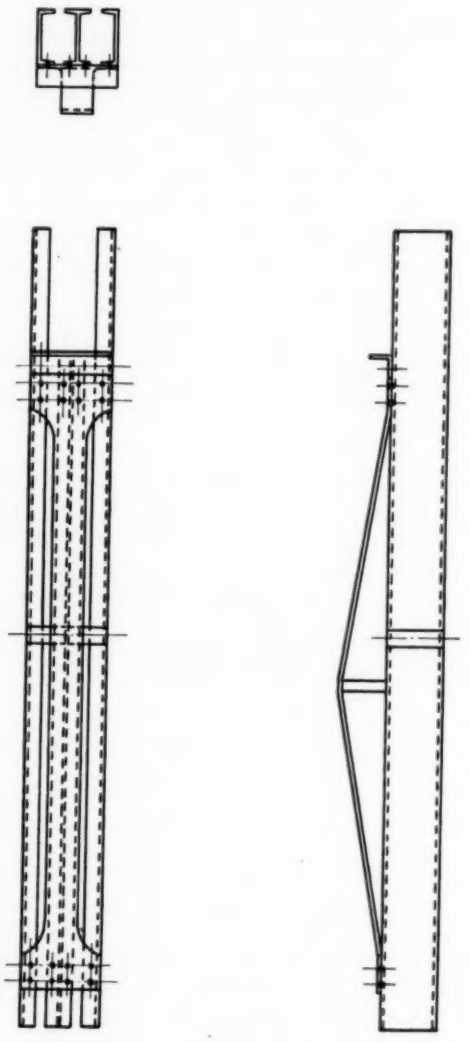
The binding should extend below the ground level where necessary to permit excavation adjacent to the furnace. This practice will be of value in old plants where the capacity of furnaces is being increased and regenerator chambers are enlarged.

Careful attention should be given to the choice of the structural section of the binding members. Not only must we select the section in the light of resisting direct stresses but the effect of local heating and the action of any impinging flame must be considered. Possible mechanical injury must be guarded against and provisions made for easy replacement in case of damage to any member of the binding.

Clearances must be ample, especially over arches.

In designing binding standard structural steel practice as to permissible stresses, connections, stiffeners, etc., should be followed.

The use of tie rods and springs for the purpose



BUCKSTAY WITH BRACE.

FIG. 7

of adjusting expansion should be considered obsolete. Expansion can best be adjusted in the brick laying. Provision for expansion should be made on furnaces operating over wide temperature ranges or on those frequently shut down.

Insulating materials as a rule, are weak in compression. Therefore this material should not be used where the compression stresses are high, as, for instance, at the skew backs.

Insulating material should be used to protect concrete. Investigate the temperature gradient

wherever concrete is used as material for a binding member.

Water Cooling: Water cooling is a very necessary evil. The use of water cooled binding members should be carefully investigated. Failure of the water supply may cause collapse of masonry through the failures of the water cooled member. Would it not be better to provide a separate water cooling element than to make the water cooling element integral with the stress carrying member?

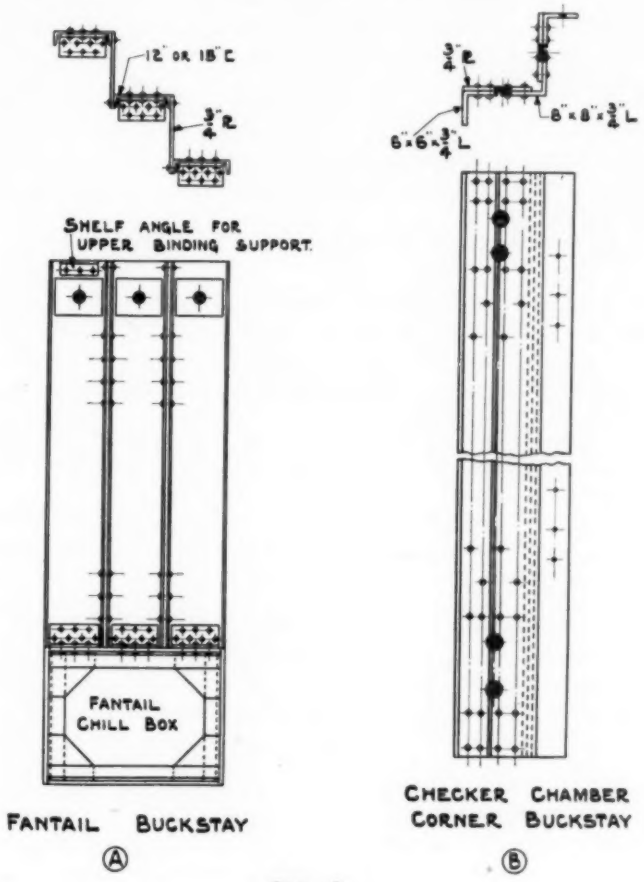


FIG. 8.

Figure 4 shows a section through a heating furnace.

Note the mass concrete in front of furnace and reinforced concrete in back of furnace. Note the insulation. Special attention is called to the plates, reinforced by angles, bolted to the concrete. It will seem that the replacement of buckstays is easy. Note the absence of tie rods and self supporting feature of the steel work.

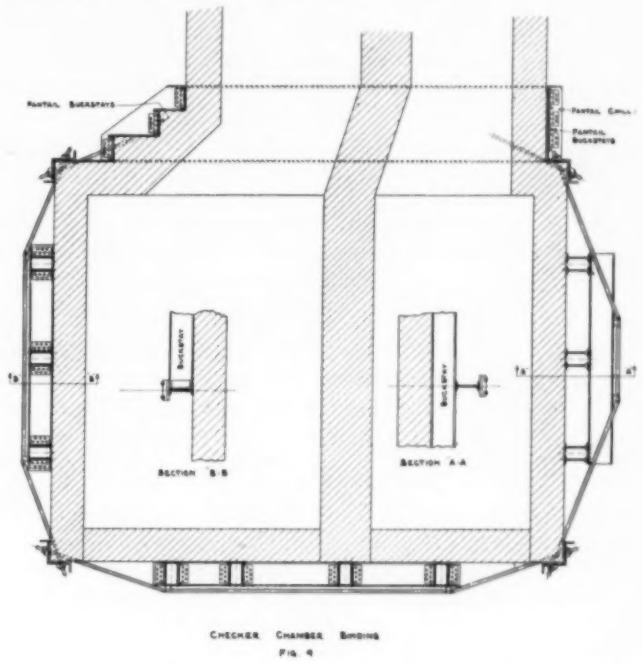
Figure 5 shows a slab buckstay with welded connection angles. Note the manner of welding angles to slabs also stiffener or spreader channels. The slabs should be at least 10 inches apart to facilitate repair of jams. A buckstay of this design has been in service for 8 months at the Lukens Steel Co.

Figure 6 shows a rigid binding. Please note the self supporting feature of this arrangement. Also note the legitimate use of tie rods. These tie rods support the buckstay near the point of greatest binding; i. e., at the skew back line.

Figure 7 shows a braced buckstay very much in favor of heating furnaces.

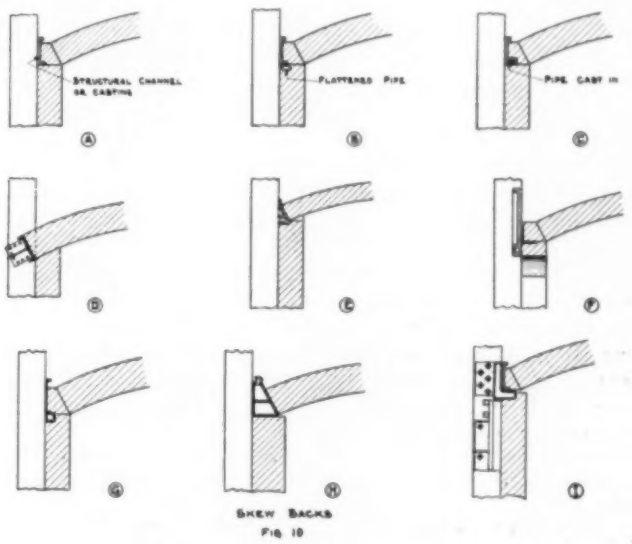
Figure 8 (A) shows a fantail binding for Open Hearth furnaces. The buckstay is a built up section riveted directly to the fantail chill. The use of tie rods is avoided at the bottom. In this case tie rods are used at the top. Note the shelf angles for supporting the upper binding.

Figure 8 (B) shows a checker chamber corner buckstay. This is a built up section.



CHECKER CHAMBER BINDING
FIG. 9

Figure 9 shows a regenerator chamber binding using buckstays shown on Figs. 8A and 8B. This binding makes use of tie rods as chord members in Queen Post trusses.



SKEW BACKS
FIG. 10

Figure 10 shows various skew back supports.

A is the conventional channel.

B and C show water cooling pipes in conjunction with the channel.

D and E show skew back supports without special skew back brick.

F shows a conventional construction for small span arches. A water cooled arch plate is shown.

G, H and I show the patented Blaw Knox construction. The construction of Fig. H may be questioned, as a failure of water supply would very quickly lead to roof failure. Figure I on the other

hand utilizes a separate water cooling member for the stress carrying skew back support.

Conclusion: A perfectly rigid binding entirely self-supporting and without any provisions for expansion in the binding would seem the logical furnace binding of today. There is at present a marked tendency in this direction. If we must and do successfully use a rigid binding for tilting furnaces, why should we use tie rods and such on stationary furnaces? Surely the service is more severe on tilting furnaces.

In closing it is only just that acknowledgment should be made of the co-operation of the members of this Association in the preparation of the paper. Blue prints of details and comments have been freely given for which the writer is grateful.

DISCUSSION

H. C. Siebert*: Mr. Chairman and Gentlemen: I don't know whether I can add anything worth while to the discussion of the paper. I was very much interested in hearing it. I recognize, however, the importance of a good binding. All of us who are familiar with the use of open hearth furnaces know that no matter how rigid or strong we try to make a binding, that strength seems to stay in it only a certain length of time. Sooner or later the buckstays become more or less weak, largely due to mechanical and thermal abuses set up in connection with the operation of the furnace.

Another factor that brings about the failure is the great number of repairs necessary, especially to the front and back walls. For instance, the heat may be three-quarters done when the walls may have failed, thus it may be necessary to force more gas into the furnace and finish the heat. Meanwhile the gases coming out around the buckstays tend to overheat them, and the stresses certainly put kinks in the binding. I have yet to see a binding, however strong it may have been made, that will stand up any great length of time. Furnace binding is an important factor and one that is bound up with considerable cost in the manufacture of steel.

C. S. Proudfoot†: I was very much interested in the paper, as it touched on a number of very important questions in reference to various methods of insulating the concrete foundation, or sub-base from the main part of the furnace. In the installation of electric furnaces we have found that where the furnace is not insulated the concrete will not stand the heat, and disintegrates to a point where it will not properly support the furnace.

I would also like to ask the speaker to what extent the water cooling is carried in the sub-base. We have a number of electrical furnaces set permanently on a foundation, but have never carried out a method of water cooling such as referred to in your paper.

W. T. Kennedy‡: The material referred to is known as Sil-o-cel, which is called Diatomaceous, which has been burned to approximately 2000 degrees Fahrenheit. The material when mixed with 20 per cent Portland cement by volume gives a product very strong mechanically, as well as a good insulator, about one-sixth as conductive, inch for inch, as fire brick, and it also withstands moisture. An additional advantage over preventing the calcination of concrete in the furnace bottom is to prevent evaporation of moisture, which is generally encountered in this location.

I think that is about all I have to add.

A. R. Tegge: The question has been raised about the insulation of electrical furnaces. I can't say much about that at all because I have no experience; however, the Johns-Manville people ought to be able to fix you up on that.

I have received a letter from Mr. Sam Naismith on furnace binders. He goes on to say that the use of tie-rods is out of date.

"The binding of any furnace is important, for, if it will not hold together the campaign of the furnace will be materially decreased. The use of tie bolts that join the back and front buckstays on any kind of a furnace is out of date. Years ago it was considered necessary to have tie-rods to that but the expansion and contraction could be taken care of by manipulation of the nuts. The large tilting furnaces of today necessarily have a more rigid binding than any other kind of furnace and we get a longer campaign on them than on our stationary furnaces, which I think is in part due to the strong rigid beams that connect the back and front buckstays.

"Expansion and contraction should be taken care of in the laying of the brick in a furnace binding that is all riveted together. Instead of driving three keys in a ring of the roof and usually shattering numerous brick on account of keying too tightly, we are driving only one key in the center of the roof in a furnace 22 feet wide, so that when the wooden center is removed, the roof drops about three inches. When the furnace is being heated up, the roof rises to its original position without spalling the brick."

I think that is quite along my contention on the obsolescence of the tie-rod and the necessity of rigid binding.

*Combustion Engineer, Bethlehem Steel Co., Bethlehem, Pa.

†Gen. Mgr., Vanadium Corporation of America, Niagara Falls, N. Y.

‡Sales Engr., Johns-Manville, Inc., Pittsburgh, Pa.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF
IRON AND STEEL ENGINEER

(Required by Act of Congress of August 24, 1912)

Name of Publication: Iron and Steel Engineer. Published monthly at Pittsburgh, Pa. (Report of April 1, 1929.)

Editor—John F. Kelly, Empire Bldg., Pittsburgh, Pa.

Business Manager—John F. Kelly, Empire Bldg., Pittsburgh, Pa.

Names and addresses of stockholders holding 1 per cent or more of total stock: None.

Board of Directors

C. S. Proudfoot, President, Vanadium Alloys Corp., Niagara Falls, New York.
F. W. Cramer, First Vice President, Republic Iron and Steel Co., Youngstown, Ohio.
R. M. Hussey, Second Vice President, Jones and Laughlin Steel Corp., Aliquippa, Pa.
A. J. Standing, Past President, Bethlehem Steel Co., Bethlehem, Pa.
S. S. Wales, Past President, Carnegie Steel Co., Pittsburgh, Pa.
A. A. Stewart, Secretary, Pittsburgh Steel Co., Monessen, Pa.
James Farrington, Treasurer, Wheeling Steel Corp., Steubenville, Ohio.
Karl L. Landgrebe, Director, Tennessee Coal Iron and Railroad Co., Ensley, Alabama.
M. J. Conway, Director, Lukens Steel Company, Coatesville, Pa.
J. E. Sayre, Director, Tennessee Coal Iron and Railroad Co., Ensley, Alabama.
I. N. Tull, Director, Corrigan-McKinney Steel Co., Cleveland, Ohio.
Edwin L. Upp, Director, National Tube Co., Gary, Indiana.
P. T. Vanderwaart, Director, New Jersey Zinc Co., Palmerton, Pa.
E. Friedlaender, Honorary Director, Pittsburgh, Pa.

Known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities: None.

JOHN F. KELLY.

Sworn to and subscribed before me March 23, 1929.

LEAH H. RUGG, Notary Public.

(My commission expires January 30, 1930.)

Utilization of Fuel in Great Britain

By T. A. PEEBLES*

My observations have been confined almost entirely to the use of fuel for the production of steam in the steel mills and central stations.

While some of the British coals are of excellent quality, most of the coal used for steam purposes would be classed as rather low grade, running on the average from 10,000 to 12,000 B.T.U. per pound as fired.

The forced blast travelling grate stoker is by far the most popular type in the British plants. Confusion sometimes results from the fact that one of the well-known makes of forced blast travelling grate stoker is known as the "Underfeed"; a name being derived from the name of the company manufacturing it, and not from the type of stoker. I was at first inclined to believe that there were quite a number of underfeed type stokers, but I soon learned that these stokers are actually of the travelling grate type.

The American practice of building travelling grate stokers in single widths to suit practically any boiler width, is not followed in Great Britain. They prefer to install two or even three stokers under a wide boiler, each stoker being equipped with its own individual drive. The drive commonly used is a constant speed motor with a gear-shifting device giving probably four different speeds, although at least one of the travelling grates using constant speed motors, is equipped with a speed changing device, giving a more flexible control of stoker speed than is secured from the four speed transmission.

The use of multiple stokers results in more furnace brickwork than would be employed under a boiler of similar size in America, and combustion conditions are adjusted to suit the particular furnace construction and to avoid excessive furnace maintenance. This results in substantially more excess air than we would consider good practice, but this is to a certain extent offset by the almost universal use of economizers. There is no doubt that the average efficiency of combustion in a given plant in Great Britain, is less than would be secured in a corresponding plant in America. On the other hand, due to the use of economizers, the efficiency of heat absorption is substantially greater, with the result that there is probably not much difference in overall efficiency. It is quite probable, however, that the American plants using economizers or air heaters are securing better results than any plant in operation in Great Britain. Such plants combine our better conditions of combustion with the same conditions of heat absorption, that apply in the British plants, and the result is a better over-all efficiency.

The smaller plants employ equipment that is almost unknown here. The Lancashire boiler is still the most popular type and is used in greater numbers than all other types combined. The large use of this boiler has resulted in the development of a number of mechanical stokers of special design, and adaptable for use in the comparatively long and narrow flues of these boilers. The combustion space is necessarily limited and combustion rates must be kept comparatively low if excessive smoke is to be avoided. This type of boiler is not designed to give low escaping gas temperatures, and as a result the economizer is considered a necessary part of an installation of Lancashire boilers. The draft loss through the boiler is unusually low, and it is in most cases possible to secure suitable draft for both the boiler and the economizer by the use of chimneys of reasonable height.

The Lancashire boiler is preferred in the great majority of industrial plants, and especially where the load is quite variable. Sudden demands for steam such as occur in many of the textile plants tend to produce an excessive drop in steam pressure. The large water storage of the Lancashire boiler has a considerable accumulator effect which tends to minimize these pressure drops.

The British practice in this respect is quite different from our own. We would employ water tube boilers, having a relatively small water storage, but would design the furnaces and fuel-burning equipment for good efficiency over a substantial range in capacity. With such a unit, the response to an adjustment of fuel and air supply is almost instantaneous, and very uneven loads can be carried with only small variations in steam pressure.

A large number of Lancashire boilers are to be found in the steel mills and coal mines, but there are in addition a number of water tube boilers, quite a number of which are still hand fired.

The gas engine seems to be more generally used than in America, and as a result less attention has been given to steam boiler plants, and especially to those in which blast furnace gas is burned. I saw nothing that could be compared with a number of the modern steel mill boiler plants in the United States. Their plants much more closely resemble the boiler plants which have been replaced in a number of our steel plants by much more efficient equipment.

*Engineering Vice President, Hagan Corporation, Pittsburgh, Pa.

*The Application of the Corduroy Crane to Industrial Plants**

By N. P. FARRAR†

Overhead Electric Traveling Cranes are necessary in the yards of steel mills and industrial plants for the economical handling of materials. These cranes are not only used for lifting and loading, but can also transport materials efficiently from one section to another.

In addition to Overhead Cranes many steel mills and other industries use the Locomotive Crane. This crane is good only for lifting and loading. Both types of cranes have been in common use for many years.

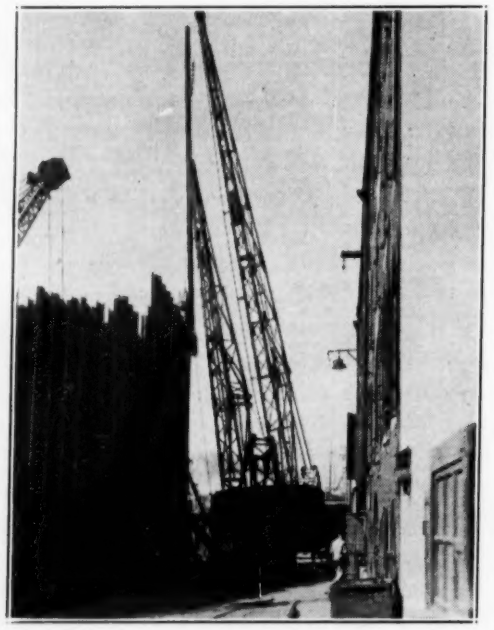


FIG. 1.

Our Company a number of years ago saw the need of a crane that could travel anywhere on the ground without requiring a fixed crane runway or a railroad track and developed the Corduroy or Caterpillar type Crane convertible to a Shovel, Dragline, Trench Hoe, etc.

This crane was first brought out for operation by electric or gasoline motors, but can now be supplied equipped with Diesel Motors.

The advent of the Gasoline, Diesel or Electric Shovel and Crane into the material handling and excavating field has almost entirely eliminated the use of steam for this purpose. The advantages of Gasoline Power over steam are a saving in fuel cost, elimination of boiler and flue troubles, elimination of water troubles and leaky cylinders also only one man is required for the Gas Crane as against two for the steam. Troubles due to freezing in the winter time are also avoided. Of the total production of such equipment about 90% is now powered with Gasoline, Diesel or Electric Motors.

The advantages of this new type Clamshell or

FIG. 2.

Magnet Handling Crane around an industrial yard is to be able to store or reclaim material anywhere in the yard without having to resort to an expensive network of tracks or building a crane runway.

This crane is extensively used for general erec-

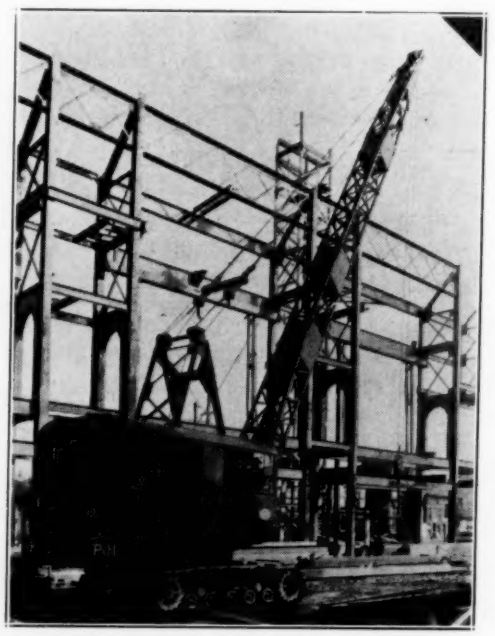


FIG. 3.

tion purposes around the yard and sometimes inside of the plant.

Many times new steel additions and repair work are required where the Locomotive or Overhead Crane cannot go and the Courdory Crane will soon

*Presented before Pittsburgh District Section A. I. & S. E. E., March 2, 1929.

†Asst. Sales Mgr., Harnischfeger Corp., Milwaukee, Wis.

pay for itself on such work. In places where there is only one track it has a distinct advantage over the Locomotive Crane in unloading cars of scrap, pig iron, sand or other materials with a magnet or a clamshell bucket in that it can handle these materials from the side of the cars, speeding up the handling and eliminating the need for shifting cars.

Industry has experienced a tremendous growth during the past ten years and I think that everyone will agree with me in the statement that the next ten years will show as much, if not a greater growth. Obsolescence and replacement alone will be large contributing factors to this growth.

Therefore, the field for this new type of Crane is quite apparent because, in addition to the uses stated above it, with shovel and dragline attachments can save thousands of dollars in doing the following work around industrial yards:

Leveling ground for new buildings or additions.
Filling in low or swampy ground.
Digging foundations.
Driving piles.
Handling stone, sand and concrete.
Unloading and erecting steel.

It should be borne in mind that in erecting steel and handling repairs in high places, these machines operating independent of tracks can be maneuvered into advantageous positions with ease, thus making it possible to complete a job in much less time and at lower cost.

FIG. 4.

These machines are being used in steel mills, foundries, scrap iron yards, oil refineries, structural steel companies, copper refining plants, mines, railroad shops, paper mills, power houses, gas works, shipyards and other industrial plants.

Contractors and contracting engineers of course use the majority of the machines of this type that are built, but the time has arrived when the engineers of industrial plants are paying more attention to the study of the application of the corduroy crane to their yard service, emergency repairs, erection and excavation work.

Such cranes have shown savings of thousands of dollars yearly. The amount that can be saved depends on the work done and the equipment or former methods compared with. The cost for fuel or electricity depends entirely on the work done.

An eighteen ton Magnet Handling Crane of the new type in ordinary ten-hour service based on 18c gas, 5c fuel oil or 3c electric current, would cost for power approximately as follows:

Gas	$8.10
Electric	7.50
Diesel	1.10

Fig. No. 1 shows two 18-ton Cranes handling sheet steel piling one crane with a 100′ boom placing the piles and the other with a 65′ boom is handling the hammer pile driver.

Fig. No. 2 shows an 18-ton Crane at a large steel plant handling a 45″ magnet on a 40′ boom loading sheet steel scrap into cars. In storing or reclaiming this material neither overhead or locomotive cranes could be used efficiently. Ground space in this plant is at a premium and after they pile the scrap as high as possible the entire crane climbs up on top of the pile to pile it higher.

Fig. No. 3 shows an 18-ton Crane for erecting steel at the new Union Station in South Bend. This method eliminates the necessity of laying a temporary railroad track for a locomotive crane, furthermore, the Corduroy Crane can turn corners and work in tight places. Erection work can be done better and at lower cost.

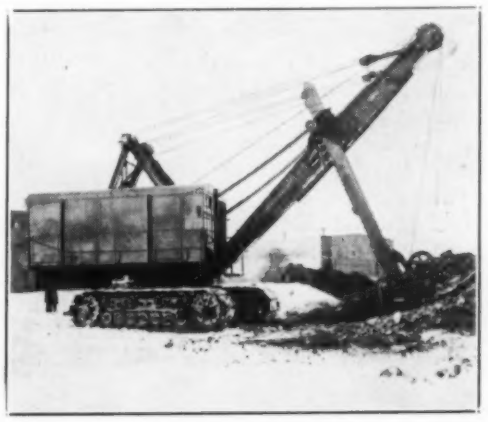


FIG. 5

Fig. No. 4 shows the storing of automobile frames in a large plant using a specially constructed boom. Four of these machines are used for this purpose. The frames are piled about 30′ high over a large area.

Fig. No. 5 shows a shovel of 3 cubic yards capacity which machine weighs 230,000 pounds. It is suitable for Industrial Plants operating Limestone Quarries and for railroad construction work.

Mill type construction is used throughout in the building of these excavator cranes. The main frames are Unit Steel Castings. The shafts and many of the gears and pinions are of forged alloy steel heat treated. Splined or squared shafting is used. Shafts and axles are ground at bearing or gear seats. Cut steel gears are used throughout and where possible, run in oil in sealed enclosures.

It is extremely necessary in this class of equipment to incorporate every safety feature possible

and in addition to the above these machines are never rated at more than 75% of their overturning capacity.

The weight of the total machine has a direct bearing on its capacity and below is a table that can be used as a capacity guide.

The weight of the total machine has a direct bearing on its capacity and below is a table that can be used as a capacity guide.

7½ ton capacity at 15′ boom radius 9000# weight of crane 39000#
11 ton capacity at 15′ boom radius 14000# weight of crane 47500#
14 ton capacity at 15′ boom radius 22000# weight of crane 67400#
18 ton capacity at 15′ boom radius 28000# weight of crane 83500#

The above machines are the ones mostly used around Industrial Plants but larger machines are also available. The normal horse power rating of the gasoline motors for above capacities should be 50, 57, 85 and 100 H.P. The heavy duty moderate speed Industrial Gas Motor of 4 cylinder type is usually used.

A new process has been developed eliminating the early troubles experienced with friction clutches on this class of machinery.

---

*Fuel Utilization Practiced in Europe**

By MARTIN J. CONWAY†

There have been many representatives of the Steel Industry in Europe recently and each has brought home some interesting and profitable information, depending upon the main object of their mission.

The features which attract the attention of American Engineers are those developments which are due to the economic situation, and are peculiar to Europe only.

In general, our European colleagues in industry are generous in their treatment when we visit their plants, and are seldom reticent in imparting the information we seek, and, a letter asking for the privilege to inspect a steel plant usually receives a prompt reply granting the permission sought.

Of the many practices I noted I am going to refer chiefly to those which are in the category of Fuel Engineering.

The Talbot Auxiliary Bath Furnace is one of the interesting furnaces in England today and is a radical departure in Open Hearth practice. Two of these furnaces were seen in operation at the South Durham Steel plant. The design is a development of the original Talbot furnace due to trade conditions.

The purpose of this furnace is to melt the pig iron in auxiliary baths at each end of the furnace, utilizing primarily the heat of the waste gases before entering the checkers for this purpose, thereby providing liquid metal from a cold charge practice.

On account of this Steel Company having to shut down one of their blast furnaces, it was necessary to revert to a cold charge at this Open Hearth. This of necessity cut down their furnace production and in order to obtain all the ingot requirements from this one Open Hearth Shop, they experimented with and developed the new furnace shown in Figs. 1, 2 and 3, and increased their production approximately 500 tons per furnace per week.

The gas enters the furnace through the gas block "A," Figs. 1 and 2, and the air through the air block "B," part of the waste gases passing over the pig iron in the auxiliary bath on the outgoing end, where-by the waste heat in the gases is utilized to melt the cold pig charge.

However, located in the air block there are auxiliary gas inlets for the auxiliary bath, and, the valve regulating the amount of gas burned in the auxiliary bath is attached to the gas valve reversing mechanism of the furnace and, therefore, the preheated air temperature is not considerably reduced passing over the auxiliary bath to the main bath because of the addition of this auxiliary gas.

Analysis of the air entering the furnace from the auxiliary bath has shown as high as 4% CO_2 content without any bad effect being noticed in the furnace operation.

The cycle of charging is as follows: The scrap is allowed to melt about 1½ hours after being charged, then the first chamber of liquid metal is added, each chamber melting approximately half of the quantity of metal required for the heat. The bath is run down to .11 to .14 carbon when the second chamber of liquid metal is added which completes the charge. The furnace being ready to tap in about 2½ hours after the second bath of metal has been added.

The average charge on these furnaces working with auxiliary baths consists of—

60% steel scrap	84 Tons
40% pig (which is melted in the chambers)	56 Tons
	140 Tons

The speed of the furnace varies from 5.5 to 6 minutes per ton of ingots.

Another interesting furnace is the Moll Furnace, or rather an Open Hearth Furnace having a Moll Port. A sketch of a typical furnace is shown in Fig. 4.

The first Moll Port was built in 1920 and was described in "Stahl and Eisen" S. 194, 1924. Difficulties were experienced in the earlier installation, due to the furnace being too sensitive and a very small difference in the pressure of the gas and air, led to serious trouble in furnace operation. Repair costs were serious, and, owing to the inefficient mixing of the air and gas, over oxidation of the steel resulted. However, these difficulties have to a great extent been eliminated and the furnaces in operation at Witkowitz and Rasselstein are doing good work.

†Combustion Engr., Lukens Steel Co., Coatesville, Pa.

*Presented before Mid-Winter Conference, Combustion Engineering Division, A. I. & S. E. E. at Pittsburgh, Pa., January 23rd, 1929.

The principal feature of the Moll Furnace lies in the provision of a water cooled preliminary mixing chamber for gas and air, with the result that a short and very hot flame is produced with consequent speeding up of the melting and reaction periods in the bath.

The preliminary mixing chamber in this system behaves in the same way as a partly eroded port.

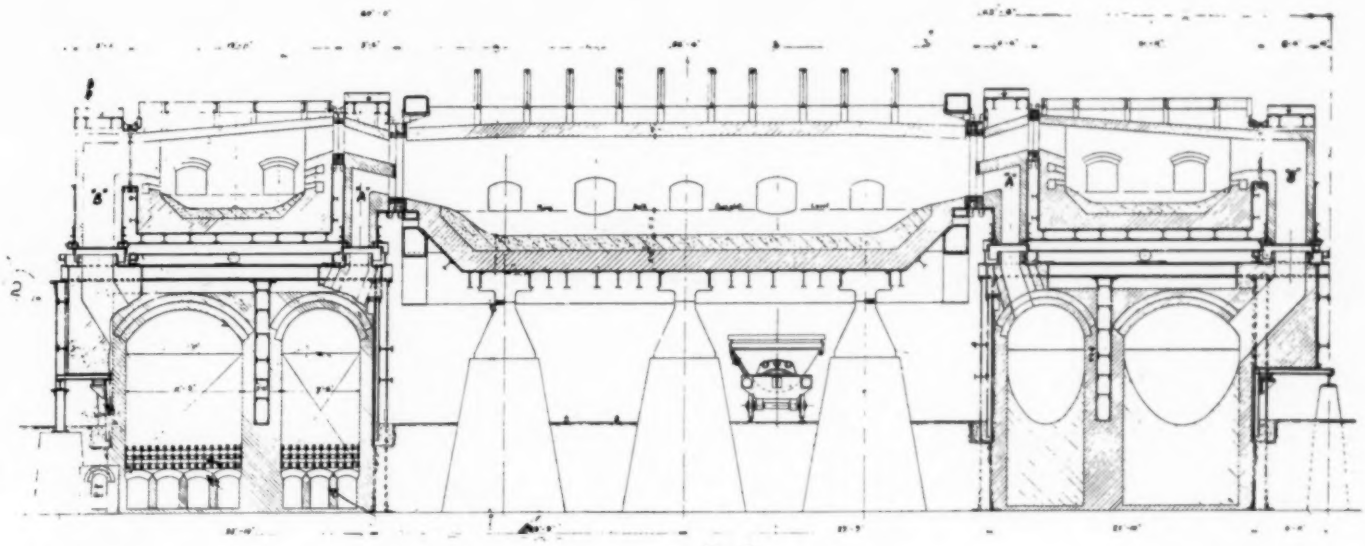


Fig 1

It is well known that a furnace works faster when a port has partly receded than it does when a port is new, but in the Moll system the water cooling adopted maintains practically constant port area and design throughout the life of the furnace, while, at the same time, the water cooled damper serves to regulate the extent of combustion in the preliminary mixing chamber and, consequently, the character of the flame entering the laboratory of the furnace.

In most Open Hearth furnace operations the air admission to the furnace is governed by the chimney effect of the regenerators. This leads to inequality of air supply, the velocity and volume of air admitted being greatest immediately after reversal and least at the end. In the Moll system the air is fed to the furnace under constant pressure by a fan. There are many theoretical advantages in introducing air under pressure to the regenerators, which have been confirmed in practice, and the use of air under pressure to regenerators necessitates air tight construction and sound masonry, which, in itself, leads to efficiency.

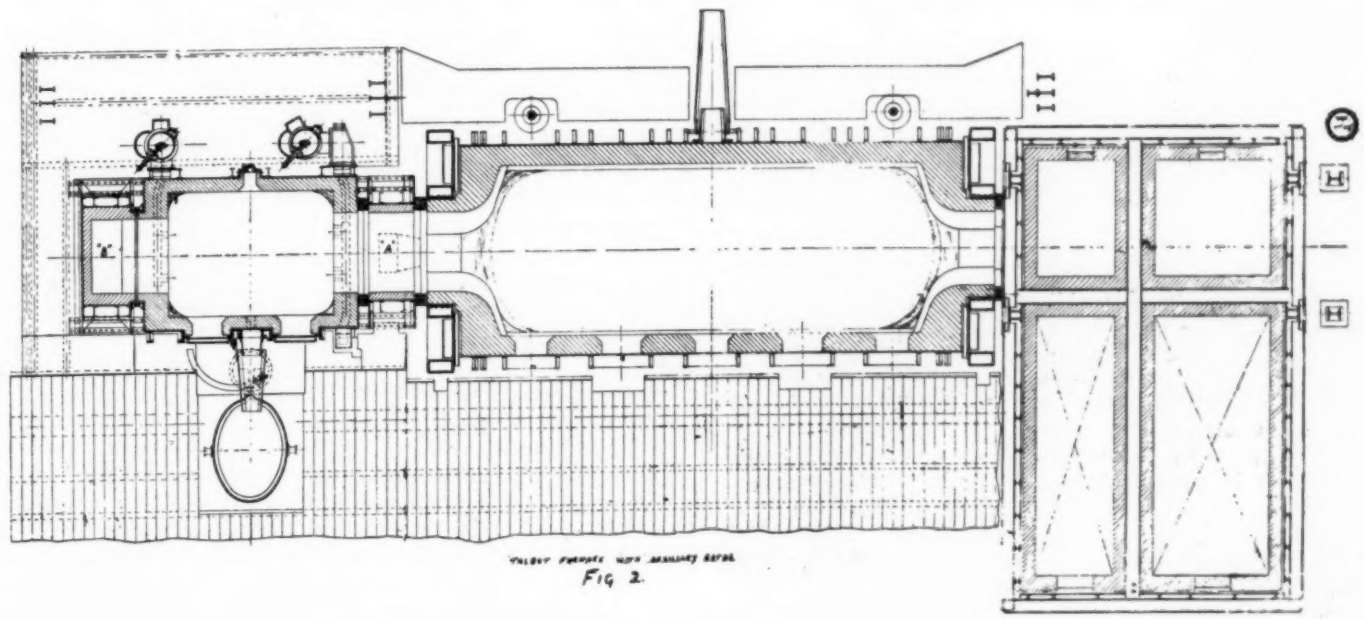


Fig 2.

Generally, the Moll furnace is a well balanced piece of apparatus containing, perhaps, no features of a fundamentally novel character, but based as a whole on sound theoretical and practical principles.

Practically in every European country of importance, organizations have been set up either by State or Industrial aid, or both, to help solve industrial fuel problems. France is falling in line with several Government and Industrial Committees, and, at the Creusot Works, a very complete plant organization is in operation, consisting of a department dealing with industrial heating, a supervisory staff for boiler and producer plant, and a Research Laboratory.

The functions of the section of this organization dealing with industrial heating, are as follows:

(1) The preparation of programs of fuel consumption in various departments of the works.
(2) The control of fuel supplies both from a point of view of weight and quality.
(3) Distribution of fuel according to its quality, to different departments of the plant in order to insure that suitable types of fuel are supplied for the various operations.
(4) A study of the best type of plant, when new furnaces are required, in conjunction with the Superintendents of the Metallurgical and Development Departments.
(5) Drafting of inquiries and specifications issued to the leading French constructional engineers, and comparative study of propositions submitted.

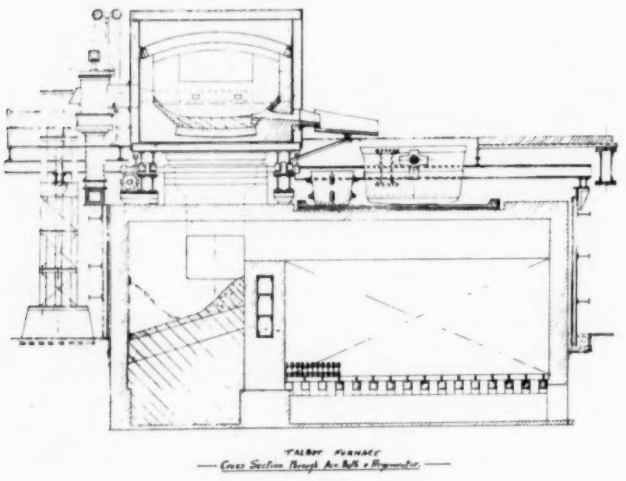


Fig. 3.

(6) After the installation of new furnaces, the supervision of efficiency tests, in the presence of representatives of the constructional engineers, with a view to verifying the realization of guarantee of production and fuel consumption.
(7) The study of existing heating furnaces, and consideration of suggestions for change or replacement by more modern or more economical furnaces.
(8) The selection of meters and other apparatus for the scientific control of furnace operation.
(9) Collection of technical information published by French and foreign scientific periodicals, co-ordination with work of constructional engineers or inventors of processes and plant and inspection trips to plants using new apparatus or new methods of heating.

All of which agrees very favorably with the work of the fuel engineering department in the average American Steel plant.

This Department is quite independent of the manufacturing side and is directly responsible to the management.

I believe the greatest improvements in fuel economy have been made in Germany. The Fuel Economy Bureau of the German Iron and Steel Association, which corresponds to our Iron and Steel Institute, have, through co-operation with the steel industries' engineers, reduced the fuel consumption in the steel industry to the extent of 15% since the War. This was made possible by a free interchange of ideas covering the whole steel industry.

The Bureau is supported by the steel industry and is made up of specialists who are continually visiting the plants, collecting data, assisting the resident engineers and suggesting new methods, or improvements on old ones, that result in greater economies, increased production and improved quality. Their activities are far reaching and enter into practically every steel plant operation.

In England the Federation of British Industries headed by Sir William Larke has its Fuel Economy Bureau with Edgar C. Evans in charge, which has done some very good work. This Department has done much for the British Steel Industry during the past few years and now holds a rightful place of importance in the affairs of the industry as a whole. The work is financed chiefly by participating com-

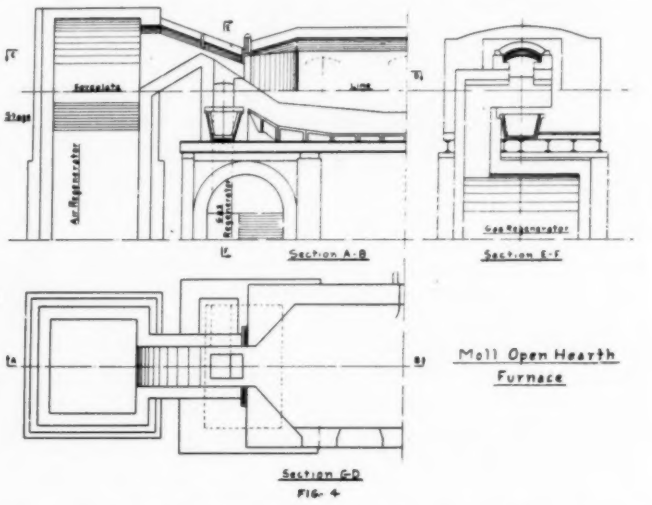


Fig. 4

panies and the Department acts as a clearing house for all kinds of information relative to fuel and power. In this way the steel companies can obtain reliable information regarding the performance of equipment and its suitability to certain conditions without having to invest large sums of money in trial installations.

Arising out of this research is the intensive development of plant and processes increasing the fuel and production efficiency of the industry.

Much investigation work is being done on the chemical and physical characteristics of coke for blast furnace work. The work of the coke research committees in England has shown the importance of resistance to shatter and abrasion in a coke, and the value of laboratory tests of these properties, but, as yet, the other properties which have been associated with possibilities of improved blast furnace efficiency, namely, combustibility, reactivity and porosity do not appear to be more than secondary in importance.

Cleaning of blast furnace gas for stoves and boilers is being adopted to an increasing extent, even at plants where there are no gas engines. Electrostatic plants have been put up at some of the British plants, which reduce the dust content of the gas to 0.4 grammes per cubic meter. At Witkowitz there is a plant of this type, dealing with 1½ million cubic feet per hour, which is reducing the dust content to 0.03 grammes per cubic meter.

In Open Hearth practice the German engineers are giving much attention to improved regeneration by building larger and better regenerators. Attention is being directed to the study of checker brick on the Continent, and several types of bricks other than the flat or square bricks are under investigation. Some of them are giving good results, where suitable arrangements are made to avoid slag deposition. In general, water cooling is not as prevalent on the Continent as in America and German investigation has shown that the cooling water absorbed as high as 11.5 per cent of the total heat used by the furnace, but that this was compensated for by better fuel efficiency and longer life of ports and doors.

In general, the heating furnace practice compares very favorably with American practice, and, due to the smaller quantities dealt with, greater care is exercised in this very important step in the manufacture of steel products.

While it is impossible to compare European and American practice on the basis of fuel consumption units alone, it is fair to assume that comparative results can be obtained by friendly exchange of practice data and the ultimate result is bound to reflect to the advantage of the industry as a whole.

---

*Material Handling Using Gasoline Locomotives**

By GEORGE D. WHITCOMB†

According to the program my talk is supposed to be on gas-electric, industrial locomotives, but I am going to take the privilege of broadening the subject a little, so as to cover gasoline locomotives in general. We might divide the gas locomotive developments into three groups:

1. A gear driven gasoline locomotive.

In this line of development you have machines ranging from a 2½-ton machine up to a 30-ton machine; and in all gauges from 18″ to standard gauge, 56½″.

2. The Gas-Electric.

On account of the higher costs of the gas-electric equipment there has not been much call for machines of this sort in the smaller range of sizes and I would say that the field for a gas-electric would be from 15 tons upwards; and on account of the motors used, in gauges from 36″ up.

3. The Diesel-Electric.

Here, again, we have an increase in cost, and I doubt very much whether there will be a very much in the way of Diesel-Electric development, unless the cost and weight of the Diesel engine is materially reduced—in sizes below 30 and 35 tons.

There are, of course, sub-divisions in each one of these groups. For instance, under the gasoline gear-driven type, we can also put the Diesel gear-driven type, and in certain fields, particularly in foreign countries where the cost of gasoline is high, there no doubt will be a call for a Diesel powered locomotive.

In both the gas gear-driven type and the gas-electric type, there will be a subdivision covering gas engines fitted with fuelizers, and gasifiers. We have read considerable in the papers of late in regard to the Mitten Management trying out some fuelizers in their busses, and burning a distillate of 38/42 Baume test.

There are other fuelizers on the market, both in the way of special attachments, and in the way of hot manifolds, to cover this range of fuel. The Waukesha Motor Company has been working on a still further advance along this line, and our company has been co-operating with them, using what we commonly term a "gasifier," and with this gasifier, we have been burning practically the same fuels as are used in a great many of the Diesel engines, that is, a 32/36 Baume test fuel, and we have run on as low as 27/30 Baume oils.

There is quite a difference between the fuelizer such as in being used by the Mitten Management, and which is used in a good many different combinations, which simply utilizes enough heat to vaporize the oil, and the gasifier, which actually cracks the oil up into its constituent gases—these gases being fixed gases and not having a tendency to condense and revert into a liquid again.

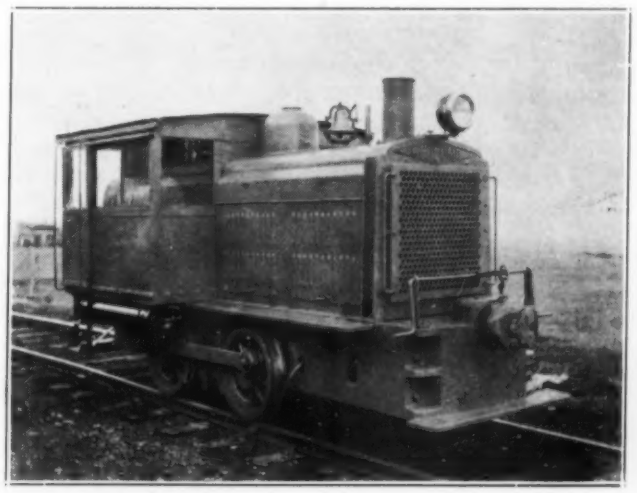


FIG. 1—Twenty-Ton Locomotive, Standard Gauge Gasoline or Oil Burning.

With a vaporizer, heats up to 500° are used, while with the gasifier heats of 1500° are used. The one, as before stated, vaporizes the fuel, while the latter actually cracks the oil up into its constituent gases.

With developments along these various lines, it is very much of a question as to which unit is the

*Presented before Pittsburgh District Section A. I. & S. E. E., March 2, 1929.

†Pres. Geo. D. Whitcomb Co., Rochelle, Ill.

most economical to use, and it will depend very much on local conditions. On a medium size installation like an industrial switching locomotive around a fair-sized plant, the chances are that a gear driven gas machine—provided too heavy a machine is not needed—would be the most economical and efficient machine to use.

If the industrial plant is spread over considerable ground and the locomotive has to get back and forth over a range of 1,000, 1,500 or 2,000 feet, a gas electric will have considerable advantage, as in getting around from one point to another, with light loads, a gas-electric is faster and easier to manipulate than a gear-driven machine.

Both of these machines will exert the same starting pull, and I would say that both, so far as low speed work is concerned, would have about the same efficiency and the same capacity. The gas-electric will be smoother in operation as, of course, there are no steps when going from one speed to the other, while with the gear-driven gas machine naturally, there is a step-up in speed when we shift from one gear ratio to another, and it is almost impossible to make these shifts without getting a little surge between one speed and another.

The efficiency of these two machines will be practically the same over a range of speed from 2½ to 6 miles an hour, but as you get into the higher speeds, the efficiency of a gas-electric machine drops away, due to inherent features of the generator; while with the straight gear-driven gas machine where there is a direct hook-up between engine and axles, it drops off in proportion to the speed. Our electric friends have been working on this feature and have made some advancement, but when they develop power on low speeds, they do not seem to be able to absorb the full power of the engine on the high speeds.

A circular came into my hands a day or two ago, covering a machine built by one of the prominent builders, covering a 75-ton locomotive, using two engines developing 550 horsepower, which on a low starting pull exerted a draw bar pull of 37,500 lbs. and with a speed of 18 or 20 miles an hour, only exterted a pull of about 3,000 lbs. according to this circular.

Using a gear-driven machine with a positive hook-up, on the high speeds you can exert at least 2 to 2¼ times this pull. On the other hand, with the average gear-driven machine, at speeds from 18 to 20 miles an hour, you would not get as smooth an operating cycle as you would with the gas-electric.

These same comparisons, of course, would apply to the Diesel gear-driven and the Diesel electric.

There is another point to consider in this connection, and that is the engines available. At the present time, engines suitable for this work are not available in units much above 300 horsepower, and on the large, heavy machines it is almost impossible to synchronize these through a gear drive, while with a gas-electric drive it is a comparatively easy matter to synchronize the two generators. We have, therefore, these various combinations to draw from, and in deciding which would be the best for any particular line of work it is necessary to take each installation and operation by itself and study the local conditions.

It is necessary to consider the following points:

1. The size of the plant.
2. The distance the locomotive will have to haul or work over.
3. First cost, cost of fuel, and last but not least,
4. The labor cost.

Naturally, a gas-electric, or a Diesel-electric, is a somewhat more complicated machine than a gear-driven Diesel locomotive, and while a man who is familiar with the operation of a truck, or gas engine plant can easily handle a gear-driven gas machine, or even a gear-driven Diesel locomotive, he is hardly capable of properly handling, operating and maintaining a gas-electric or a Diesel-electric.

An engine fitted with a fuelizer, or gasifier, would come under the same classification as a gas machine, as these accessories are no more complicated than the ordinary carburetor.

In considering economies in gas, or fuel, I find that there is a tendency to exaggerate the importance of fuel, particularly on industrial switching. I am not discussing main line hauls, or long hauls, but simply industrial switching—that is, switching around the plants or yards where the hauls are short, and the distance traveled in a day is comparatively short.

We have checked up on a good many installations and we find that over a day's run, with the average switching locomotive the engine is not developing its full rated power for over 15 or 20% of the time. The General Electric Company checked over one of their big Diesel-electric locomotives in the same way, taking in a full year's operation, and they found that over a year's operations, and during this year they had used it in all three different switching jobs, that they only used about 16.6% of the full rated power of the engine on an average, over a day's run.

Naturally, this very materially affects the fuel consumption. For instance, we have several gear-driven gas locomotives, weighing about 25 to 30 tons, in operation in the Buffalo district. These are fitted with engines capable of developing about 180 horsepower. On a block test, running at three-quarters to full load these engines will use about .6 of a pound of fuel per horsepower per hour, burning gasoline; therefore, with 180 horsepower, running full load, they would burn 108 pounds of gasoline per hour. Gasoline weighs about 6.2 pounds to a gallon; therefore, this engine would be capable of burning 17.4 gallons per hour, or 174 gallons in a 10-hour day.

The facts of the case are—these locomotives are averaging around 30 to 35 gallons of fuel per day, or around 20% of their full rated capacity. Similar results were found in checking up the Diesel-electric; and for this reason, in checking over the work to be done, it is not correct to figure a certain amount of horsepower available, and figure you will use so much of fuel per horsepower per hour; as you would come nearer being right in using the same basis that I have, that is, calculate the maximum the engine is capable of burning, then take about 20% of this for the actual fuel consumption.

In making a comparison between the efficiency of the gasoline engine—an engine fitted with fuelizer—an engine fitted with gasifier, and a Diesel engine, there are a number of points to be considered.

1. The cost of fuel, and

2. The fuel consumption.

On a block test, a good, well designed gasoline engine will develop one horsepower for one hour on about .6 of a pound of fuel. With fluctuating loads such as we get in locomotive practice, the chances are the fuel consumption will run nearly .7 of a pound per horsepower per hour.

With the average fuelizer, or hot manifold arrangement, burning 38/42 fuel, you will not get as good efficiency with the low grade fuel as you would with gasoline. Our experience with devices of this sort is that we get around 15 to 20% less efficiency with the average fuelizer than we do with straight gasoline. Some manufacturers, however, in these later developments, claim they will get equally as much efficiency, that is, using the low grade fuel, they will develop as much horsepower with an equal amount as they will with gasoline.

With a gasifier we have been getting about 20% more power per gallon, than we get with gasoline, burning 32/36 Baume fuel, and of course, with the Diesel engine you get a considerably better efficiency.

In determining this efficiency, we must not overlook the fact that the lower grade fuel weighs very much more than gasoline. For instance, gasoline of about 56 Baume test will weigh 6.3 pounds per gallon, and if you develop power on the basis of .6 of a pound per horsepower per hour, you would get a little over 10 horsepower hours out of a gallon of gasoline.

A distillate of 38/42 such as is used with the fuelizers will weigh from 6¾ to 7 pounds to a gallon; therefore, if you are only developing the same amount of horsepower per gallon with this fuel that you are developing with gasoline, you are really not getting as high an efficiency per pound of pull as you are with gasoline.

With the gasifier, they are showing a fuel consumption of about .55 pounds of fuel per horsepower per hour. This is on a block test, and all of these figures are based on block test at ¾ to full load.

A 32 Baume test oil will weigh about 7.2 pounds to a gallon and if we are using .55 pounds per horsepower per hour, we are getting a little better than 13 horsepower hours from a gallon of 32 Baume fuel, or an increase of nearly 30% over what can be done with the same engine operating on gasoline.

With a Diesel engine on block test, assuming the engine is a moderate speed engine, builders claim around .46 pounds of fuel per horsepower hour, and if they burn a 27° Baume test fuel, the fuel would weigh about 7.4 pounds per gallon; therefore, they would be capable of developing around 16 horsepower hours per gallon of fuel.

These figures, however, are a little misleading for the reason that a Diesel engine does not lend itself to rapid fluctuations as readily as a gasoline engine and I have discussed this matter with a number of builders of Diesel engines, and they are inclined to think that on fluctuating loads such as we get in locomotive practice, the fuel consumption per horsepower per hour will range from .52 to .55 pounds per horsepower per hour.

There is not as much increase due to fluctuating loads with gasoline engines as these engines are more flexible and better adapted to fluctuating loads than a Diesel engine.

Therefore, in considering the importance of fuel consumption, we not only have to take the first cost of the fuel, but the efficiency of the fuel, and of course, in balancing up the whole subject, we have to take in the first cost of the locomotive, cost of labor and cost of fuel; and naturally the interest and depreciation and amortization on the Diesel locomotive is very much higher than on the gasoline locomotive.

The gasoline machine fitted with the gasifier is comparatively little higher in cost than the straight gasoline locomotive; therefore, in considering these figures, that is, interest, depreciation, etc., when comparing a gas with a Diesel, we can use the gas figures as covering the 3 classes, viz. the gas, gasoline engine fitted with a fuelizer and gasoline engine fitted with a gasifier.

As a rule, the cost of the 32/36 Baume fuel in the United States is about one-third the cost of gasoline. There, of course, is no gas tax on the

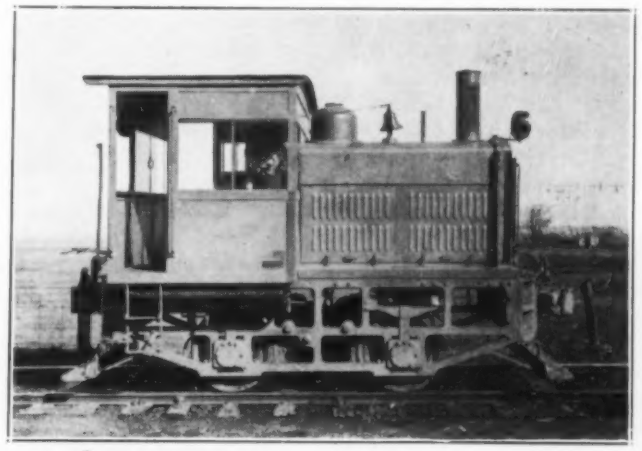


FIG. 2—Twenty-Ton Standard Gauge Oil-Electric Locomotive.

32/36 fuel, but as a rule the gas tax will not apply to industrial work in any event.

The cost of the 27/30 Diesel oil over the United States, will run from two-thirds to three-fourths the price of the 32/36 fuel oil.

You can readily see from these various figures that it is not wise to jump at conclusions, but that each case should be taken by itself, balanced up, taking the first cost, depreciation, operating costs, etc., as against the fuel cost, and this will determine whether or not a gear-driven gas, a gas-electric or a Diesel-electric is most economical and best suited for the work to be done.

On the other hand, comparing any of these machines with a steam locomotive, there are a number of other factors that come up for consideration. A steam machine will be considerably less in first cost than any of the above machines, but it does not lend itself very readily to fluctuating loads, and you get, very largely, a constant fuel consumption regardless of the operating cycle, while with the gas, or gas-electric, the fuel consumption is almost directly in proportion to the actual work done.

With a steam locomotive, in order to have it available when wanted, and as wanted, the fire has to ke kept up and steam generated at all times so as to meet more or less maximum conditions. Steam locomotives have been in use so long, that I find

they have been accepted as more or less of a standard, and have been considered quite efficient; but of late, I find that people who have occasion to use locomotives are studying the question of the efficiency, cost of upkeep, etc., of the steam locomotive as against the gas, or Diesel locomotive, and they have been very much surprised.

The writer recently had occasion to go over several different operations. In one large operation they had fourteen steam locomotives and after the matter was started, we suggested that a systematic check over a year's operation be made to find out just what it had cost them to operate these steam machines.

They found that the operating cost, including fuel, lubricating oil, supplies, wages, necessary overhauling, depreciation and installation had run up to the astounding figure of about $269,000 or over $19,000 per locomotive. They could hardly believe their own figures and took occasion to check back and verify them. It is needless to say, this company now is very seriously considering replacing all of this equipment with the gas, gas-electric, or electric locomotives.

Another case where they had one 45-ton steam locomotive, they found that during 1928 it had cost them nearly $12,000 to operate this machine around an industrial plant.

Still another case, where they are operating a 50-ton machine over a four-months' period, or 117 working days, they found their cost of operation, upkeep, including interest and depreciation, was some $5,000.

I understand a good many of the large iron and steel companies are now very carefully studying this whole problem and are finding that as against steam locomotives, gasoline, or gas-electrics will effect enough saving to pay for themselves in a short period.

In figuring the cost of a steam locomotive you would not only have to take into consideration fuel consumption, cost of fuel, cost of wages, interest and depreciation and such items, but as a rule, there are auxiliary expenses such as handling fuel, making provision for water, removing and disposing of the ashes, overtime work on Sundays such as cleaning boilers, tightening flues, and everything of this sort. In some cases I have found that what they term hostling charges, that is the cost of bringing up fuel, getting rid of ashes, and such items as this, equal, or exceed, the cost of fuel.

Again, in cold weather, there is the standby expense of taking care of the locomotive during the off period at night, for steam has to be kept up for twenty-four hours, care used so that drains, valves, and everything of this sort do not freeze up.

On the large locomotives there are generally two men on the locomotive, an engineer and a fireman while on the gas or gas-electric there is no need for more than the operator. With a steam locomotive a good many of these expenses are not segregated from the general accounts, and a good many of the items that should legitimately be charged to steam locomotives go into the general expense, such as a man on at night to look after the locomotive, who also acts more or less in the capacity of a watchman, expense of Sunday work; as well as getting up coal, taking care of the water, etc. These are accepted as items of necessity and classed as general expense, while they are really operating expense.

With the gas and gas-electric locomotives, as they are independent pieces of machinery, with no connection with other machinery, all of the expense is directly charged to the locomotive operating expense, and sometimes unfair comparisons are made in regard to upkeep. I have checked over a good many installations and the upkeep cost on a gasoline or gas-electric locomotive, is remarkably low. Particularly so if a fairly competent man is put in charge of the locomotive and made responsible for it.

I would say, offhand, that 5% per year of the cost price of a machine of this sort would more than take care of the ordinary annual upkeep expense, and in a great many cases the upkeep cost has been but a trifle of this amount.

As a gasoline, or gas-electric, locomotive is available on a moments notice, can do the work on hand, and can then be shut down and will not be burning any fuel, it is a very much more convenient means of industrial switching than a steam locomotive that takes an hour or two to prepare for work, unless steam is kept up over night—and cannot be shut off when the work is done, to any extent. For instance, in our own plant, which is a comparatively small plant as compared to a lot of big steel plants, we put the man in charge of our shipping department, in charge of the locomotive. When he wants a car spotted for loading, he starts up the locomotive, shifts his cars around in place, shuts the locomotive off, goes about his loading. When the car is loaded, he starts the locomotive, shifts the car out, and shifts in another car.

We know of a number of other plants. For instance, the Rockford Electric Company. They let the man take the locomotive in the morning after the railroad has set in a number of cars of coal, unload the coal, put the locomotive on the side track, shut it down, and he then takes the truck and does the pick-up work around town, the one man being used for the two jobs.

Again, in a great many large plants, the man is on the locomotive all day, but as it only requires one man, it is not a very serious matter.

We have checked over installations where we have found that with the use of a gasoline or gas-electric locomotive the cost of shifting the cars drops down to a mere fraction of what it costs with steam, but there are so many varying conditions to be taken into consideration that it is very difficult to get exact figures, and I would suggest that if any of you have problems of this sort, you very carefully and systematically check all of the conditions, balancing up the first cost, efficiency in operation and cost of the fuel.

In making estimates along these lines, in a rough way, the relative costs of the various machines can be figured on about the following basis:

A gear-driven gasoline locomotive as a base, at		100
A gear-driven gasoline locomotive with fuelizer or gasifier	110	115
A gear-driven Diesel locomotive (depending upon the type and make of the engine	150	160
A gas-electric locomotive		200
A gas-electric fitted with a fuelizer or gasifier	205	210
A Diesel-electric (depending upon type, make and speed of engine)	275	300

There of course will be some variations and fluctuations from this basis but in a general way, for estimating purposes, about in proportion to the whole.

One Hundred Days Without An Accident*

By R. F. GALE†

On Monday, March 25, 1929, The Midvale Company, Philadelphia, completed a run of 100 days without a lost time accident, with approximately 1,950 men on the payroll.

Previous Records

64 days ending December, 1926
98 days ending March, 1927
74 days ending May, 1928
62 days ending August, 1928
103 days ending in March, 1929

It has taken twenty long years to accomplish this.

Looking over the records, I find May 2, 1906 as the first mention of a safety precaution. It gave the location of stretchers throughout the Works for use in case of accident or illness.

General Order No. 25 to Department Heads, dated August 11, 1908, read as follows: "When it is reported by a workman that machinery, equipment or conditions surrounding him are unsatisfactory or unsafe you will please have the facts reduced to writing and at once confer with the Engineers Department, looking to a rigid investigation by the Safety Officer, and a consequent correction if necessary, etc., etc."

About the beginning of 1909 Mr. Eugene W. Yearsley, Electrical Engineer of the then Midvale Steel Company, returned from a Pittsburgh meeting of the A. I. & S. E. E., bringing home the first constructive safety ideas.

For several years the safety movement was almost entirly along the line of mechanical safeguards, with little or no effort toward education. Within a year the Company put an organization into effect, including safety committees. Certain days were allotted to permit inspection of shop conditions. This resulted in a very large number of orders for the fabrication and installation of gear guards, etc.

Many schemes, both competitive and otherwise, were tried throughout all these years. Some progress, even though very little, can be considered as having been made up to the first of 1927. All this time I personally found myself extremely closely related with each and every effort and activity, not only those inside the Works, but those of the State Safety Inspectors as well. I attended meetings in Harrisburg and assisted in formulating codes, etc. It proved an exceptional educational advantage to me, and I confess has been most self-satisfying.

Lost Time Accident

The definition of a lost time accident, as per the National Safety Council, is as follows:

> "LOST TIME ACCIDENT shall be an accidental injury, arising out of and in the course of employment, causing death, permanent injuries (such as the loss of, or loss of use of a finger, eye, etc.) or loss of time other than the remainder of the day or shift on which the accident occurred.
>
> "NOTE: No matter what time of day the employee is injured, if he returns to his job at the beginning of the next regular shift, and with no permanent disability, the accident shall not be counted as a lost time accident. If he returns after the beginning of the next shift, or if his injury has resulted in any permanent disability, the accident is counted as a lost time accident and his record is charged with the loss of a full day, unless the delay was due to stopping at the doctor's office, in which event the doctor's decision should be obtained as to whether the injured man was able to return to work at the beginning of the shift."

Since 1927 the lost time accidents in Midvale tabulate themselves as follows:

Year	Average Number Of Employees	Number of Accidents
1927		
1st 6 months	1725	16
2nd 6 months	1760	15
1928		
1st 6 months	1800	9
2nd 6 months	1900	9
1929		
January	1950	0
February	1950	0
March	1950	1

About July of 1927 one of the members of the staff brought forth the idea of departmental rallies as a publicity movement, immediately reducing the accidents nearly 50 per cent.

These rallies were short and snappy and took place about five or ten minutes after the twelve o'clock noon whistle, lasting twenty to thirty minutes. The members of that department any any others interested congregated at the given point. A small 6x8 platform was erected two or three feet above ground level and the meeting proceeded, generally under the guidance of the head of the department, together with the Safety Engineer of the Works. Men of high position, up to the President, were present. The meeting started off with all seriousness with introductory remarks by the head of the department. Sometimes a short musical number of similar attraction was given by one or two members of the department. The department superintendent talked on the safety idea primarily along educational lines, emphasizing and forcing his arguments so far as possible with the use of short stories or similes. One of the foremen then gave his views in order to accentuate the safety educational idea from the workman's standpoint.

This constituted our first real progress toward the reduction of accidents. The improvement exceeded by far the results of any previous method. It was felt, therefore, that as intensive education tended to further reduce accidents, we should spend our effort along that line. To insure this idea getting to each and every workman, let us look into organization that will best accomplish this result.

To give the movement the seriousness and pres-

*Presented before Philadelphia District Section, A. I. & S. E. E., Saturday, April 6, 1929.

†Plant Engineer, The Midvale Co., Philadelphia, Pa.

tige it deserves, the organization of necessity must start with the vice president and general superintendent of the Works. Either of these officers appoints a Safety Engineer of the Works and a Works General Safety Committee of an even number, six or eight, including one or two department superintendents, one or two foremen, one or two workmen, preferably of different departments, and so far as possible one half conservative and the other half radical and aggressive. This committee is to serve for a 6-months terms, at the end of which the personnel is reviewed by the vice president or general superintendent and some changes are made where necessary for the good of the service. It is highly undesirable to change the entire personnel at one itme. Those that have progressed to such an extent that they can be considered as an aggressive safety agent at large, are replaced with the stubborn, cantankerous argufiers against safety. In other words the safety committees, General or Departmental, function as a school primarily to change a RADICAL "AGAINST" to one "FOR" safety. The graduates are thanked for their services and are given to understand their presence or suggestions will always be most welcome. They really become members ex-officio.

At The Midvale Company these meetings are held once a week, usually on Mondays, with the Safety Engineer of the Works acting as chairman. They are called by the chairman any other time he feels necessary. A secretary is appointed and an alternate chairman is elected. The meetings are conducted in true parliamentary fashion, and no horseplay or foolishness is tolerated. Minutes are taken and forwarded to the vice president in charge of operations for their information and criticism.

Department Safety Sub-Committees

Committees, known as Department Safety Sub-Committees, are appointed by the department superintendents such that each member represents not over 30 to 60 workmen. Each of these safety sub-committees elects a chairman and holds meetings at least once every two weeks. A secretary is appointed and minutes of the meetings recorded. These minutes are forwarded to the general safety committee of the Works for their information and criticism. Each member of these departmental safety sub-committees should have an alternate to insure a full attendance; no excuse is accepted for absence. Each member should be instructed to acquant his alternate with all the business carried on at the meetings, or any other safety activity. Once a month the departmental safety sub-committee should include the alternates as well as the members. The head of the department should be present. The idea of alternates is to organize a source of supply for committee members for future years.

Each member of the departmental safety sub-committee should furthermore understand that he represents a certain group of certain men, and is to carefully impress upon each of his constituents that he is their representative on safety matters and is to look out for their interest. There should be no question in the mind of any workman as to who represents him on the safety committee, and should any unsafe practice or accident present itself the workman must immediately see to it that notification is given to his safety representative as well as his foreman at the earliest possible moment, whose duty it will then be to arrive on the scene and gather in all evidence and assist in making out an intelligent report.

Similarly each member of the general safety committee should have a certain department or a group of departments for whom he is personally responsible. He should take the necessary steps to obtain and receive full and hearty co-operation of the superintendents of these departments.

Unless this organization is 100 per cent co-operative, it will fail. The one idea of the safety movement is to stop accidents, regardless of the subject being discussed. Whenever there is an accident or a near accident or an unsafe practice condition, even though it may appear asinine, it is well to call a meeting of the sub-committee, or possibly the general committee, at the scene and go over the ground in person in order to thoroughly familiarize all present as to conditions and discuss the proper procedure which would lead toward the prevention of a similar accident. These meetings improve the efficiency of a safety committee similarly to fire drills improving the efficiency of a fire gang. It affords an opportunity for rehearsal, which means education.

Often at these meetings newly appointed members and some who have not advanced as far as others on the safety movement think of prevention involving mechanical safeguards or change of practice or magnitude of injury instead of education, and remember, a man is as safe as the tool he uses or his surroundings.

We have found it beneficial to rule out this kind of procedure or conversation in order that all present get the maximum benefit of the idea that a man is as safe as the tools he uses. In some cases it may prove highly advantageous to discuss and investigate from the standpoint of one or all of these three, but it is best to postpone same until another meeting can be called at a later date so as not to encroach upon the educational effort.

Throughout all meetings formal, orderly conversation and discussion persist along very definite lines or purposes, rather than general lines. Generalities should not only be discouraged, but not permitted. We have found that an organization and procedure as above outlined reaches each and every individual workman and foreman. If nothing else is done the men get into the habit of talking safety among themselves, some seriously, and some foolishly, and some super-accurately. In any case, progress will result. Men today now absorb new ideas or education very eagerly, and guards or change of practice do not inspire them as they formerly did.

Accident Reports

We now come to the method of reporting accidents. We at Midvale have tried out many designs and forms. In fact we found it stimulates the mind to change this form every six months or a year. It invites discussion, and anything that invites discussion about safety certainly helps safety, no matter if the discussion at the moment approves or disapproves. Heated discussion or criticism very often occur, even to the extent or being personal, but they all help.

The following design is now on trial:

THE MIDVALE COMPANY

FOREMAN'S REPORT OF ACCIDENT

To Be Forwarded to General Safety Committee

Name	No.	Department
Foreman		Date of Accident
Occupation		Time of Accident
Nature of Injury		Date of Report
Place of Accident		Witnesses

1. This accident was caused by:
2. What safety rule, written or otherwise was violated?
3. State name of this man's safety instructor.
4. Was there any indication or evidence of alcohol?
5. What immediate steps were taken to prevent recurrence?
6. What steps were taken that would lead to permanent correction of the situation?
7. What was done to broadcast this?
8. State nature of reprimand and by whom.
9. What did witnesses do to prevent this accident.
10. When did man go to Dispensary?
11. When did man return to work?

Shift Foreman———————————

NOTE:—This form is to be filled in by the victim or his immediate superior and directly following the accident, i. e. on the same turn, and forwarded to the department superintendent for transmission to the General Safety Committee.

It is insisted that these field reports be made out promptly and pass through the safety representative, foreman, department superintendent and on to the general committee, each having thought carefully and assisted toward making the report as complete and as thorough as it is possible to make it, never overlooking an opportunity to give constructive criticism such that better and more complete reports follow, which in itself enforces education with the tendency to reduce accidents.

One of the most important questions on our latest form of Field Report of Accident is "What did the witnesses do to prevent the accident?" In other words, where is there any evidence of one man acting as his brother's keeper.

These Field Reports do a great deal towards broadcasting accidents, and those not pertaining to lost time are generally investigated fully as carefully as if the man had lost time, making it a reportable accident and breaking the record.

Discipline

We now come to Discipline. What is Discipline?

Webster's dictionary gives the following synonyms for the verb:

1. Train
2. Teach
3. Instruct
4. Regulate
5. Correct
6. Chastise
7. Punish
8. Improve by corrective and penal methods through suffering.

Each and every one of these synonyms must be used emphatically to the fullest extent to make any real progress toward stopping accidents. To make long no accident runs new ideas and methods intensively used are absolutely necessary. New ideas, methods and publicity keep the minds active and encourage originality. All these activities are used along purely educational lines, emphasizing that men are judged by their buddies, encouraging an active, not passive attitude, aggressive if necessary. One soon gets to the point of forceful education. To enforce this education serious reprimands and apparently unjust procedures have to be adopted.

The object is to reduce accidents even to the extent of being unfair or unjust. It will produce spirited arguments, and to argue safety at least reduces accidents. Better be cruelly unjust if it tends to stop an accident than be fearful and have one.

If these educational methods are not thoroughly and intensively promulgated by the department superintendents, foremen and committee members, accidents will result and constitute the evidence of dereliction of your duty to your fellow man. The foreman's duty primarily consists in training the men hitherto to perform their work correctly, thoroughly and economically. Within the last year the additional qualification has been added to train men first and foremost to work safely and see that others work safely. It must be impressed upon the mind that if one of their co-workers is injured they themselves are very much responsible for not having prevented him taking chances and getting hurt.

It is the duty of the supervisory force to point out to the men this advantage and instill into their minds this habit and make them realize their responsibilities. I can recite instances where a man has actually prevented his buddy from getting seriously hurt because of his forethought and his co-operative attitude. Investigations of accidents and near accidents constitute about the only way those in authority can be convinced that safety and safety habits are being preached such that the workman has absorbed and has really gotten the idea. The subforemen and gang bosses find themselves continually forced to examine and check up the safety committee representatives by asking the various workmen test questions. Thoroughness is never fully realized without checking, on work of any nature. Up to a year ago this safety idea was a hit or miss proposition; lots of talk, but nothing much to the point. No definiteness was exhibited.

Finally now we have arrived at a condition where the foreman has the tendency to blame the unfortunate workman when in reality the foreman himself is at fault. The emphasizing and broadcasting of near accidents will certainly reduce accidents. When the mind of the man makes him safe he certainly will become more efficient. Efficient men are needed and greatly desired, not only to make themselves bigger, but better. It is just as necessary in business to improve the men as to improve the product.

If we deliver the goods we progress—not only do we keep our jobs, but if we always do a little more than we think we are paid for, and do it long enough, advancement will surely follow. Interest and activity on my part on safety campaigns and safety ideas I freely confess has made a better man out of me; it has improved my disposition; it has increased by tendency to be fair and more open minded and many other benefits too numerous to mention.

One night about a year or two ago I was thinking out safety improvement possibilities, and the idea presented itself to lay off a gang if one man in

it got hurt. With great fear and trembling I put it into effect. There has been six or eight instances when this was done. Some dissatisfaction on the part of the men presented itself. It took a long time to impress upon them why they were being sent home when one of their buddies got hurt. Finally on a long run of ninety some days the department safety sub-committee of their own volition unanimously voted to recommend a lay off. Through no effort of Midvale it was printed in a Department of Labor and Industry pamphlet of December, 1928, as follows:

> "When a 92-day record without a lost time accident was terminated recently at the Midvale Steel Company, the Midvale safety sub-committee sat in judgment on the 9 men who were in the vicinity when a worker had his right foot broken by the fall o fa heavy pipe flange. The sub-committee decided that any one of these 9 men could have prevented the accident had he been sufficiently 'on the job.' Each of them was given a lay off for one day. The average number of employees engaged in this drive was 1,875. The accident which ended the record came as a great disappointment to the workers who had hoped to break their best previous record of 98 days." ....

It hurts to get hurt. Even thought it is known who or what is responsible. Regardless of the magnitude of monetary recompense the loss of time, economic waste, suffering or crippling of the body is still a very undesirable condition of affairs. No amount of money can encourage one to lose an eye or permit himself to get injured. No talk, arguments, or fixing the cause and responsibility for an accident will alleviate the suffering or pangs of remorse, so let us resolve to do our utmost in stopping accidents in the first place.

As previously stated I put into effect the sending of the entire gang home when one member got hurt or was discovered doing something unsafely.

This of necessity puts each workman responsible for the well being of his buddy. The man injured suffers not physically so much as with the troubled conscience that he has been the cause of his buddy suffering financially.

The more fortunate remainder of the gang when sent home are made to feel their responsibility to their fellow man and will more thoroughly insist that dangerous practices are put in the background. I have actually heard men volunteer to take a day off if it would tend to prevent a man getting hurt.

Very often I hear executives say to discharge an unsafe workman. This is an example of weakness, and should be done only after all other methods of persuasion fail. This has long since been acknowledged on matters pertaining to errors in workmanship or abuse of machinery.

The man certainly has profited by his experience and why let another concern get the benefit of a man's shortcomings with you until you have exhausted every effort to obtain that benefit yourself.

We got to the 104th day March 28, 1929, at 9:45 A. M., when an ironworker in the Engineers Department, working with 5 others on dismantling a forging furnace, succeeded in breaking his leg through either his own negligence or negligence on the part of the men working with him. This ended our 103-day no accident run. The injured man was sent to the hospital and the rest of the men, 5 in number, were laid off for the balance of the week, losing about two and a half days each.

The Engineers Department safety sub-committee, made up of 7 workmen, were on the scene within a half hour. They questioned each and every man, and immediately saw that the men on the job were not sold 100 per cent on safety, and did not hesitate to so express themselves. The member of the committee representing these workmen was in no uncertain manner made to feel that he had failed on putting safety across to those he represented.

While we only got on our third day on our second 100 days, we have not permitted ourselves to be discouraged. We simply are going to work that much harder and put the safety idea across that much more permanently and more plainly.

I did not intend to take up so much time as this, but it seems to be one of the high points in steel plant operation today, and although it is a side line to my own activities, I consider it in the front rank, and I sincerely hope that I have conveyed some food for thought that can be taken home and revamped or altered to suit the condition in any other plant.

If any idea does take root at this meeting and prevents a single accident, I believe that we should feel that we have not spent this extra time in talking about safety in vain.

DISCUSSION

Martin J. Conway*: The Midvale Steel Company and Mr. Gale ought to be highly recommended for the work they are doing to foster safe practices among their workmen. When we stop to consider that in a single year the number of fatal accidents occuring in industrial plants and elsewhere in the United States is greater than the number of men we lost in the World Wor, it is very important that we do something to prevent accidents. The actual cost of accidents per capita in the United States last year amounted to $26.00. It is necessary that we do all we ca nto prevent accidents and endeavor to follow The Midvale Steel Company's example by using intensive accident prevention measures.

Geo. Pfeffer†: There is one question I would like to ask Mr. Gale. You spoke about laying a man off in case of an accident. Does that mean a lost time accident if he is laid off the following day or two days for carelessness?

R. F. Gale: Do you mean the man hurt?

Geo. Pfeffer: Yes.

R. G. Gale: No. The Works Surgeon is the sole judge as to when a man is able to return to work, and orders him back to work accordingly. Should a man be ordered in by the doctor, which means he is perfectly able to work, forbidding him to come to work by the department superintendent would not constitute a lost time accident. However, since this is likely to be abused or misinterpreted, a man is usually permitted to work a few days and then is or is not laid off. The injured man is rarely laid off if he is injured to the extent that there is likely to be a question.

*Fuel Engr., Lukens Steel Company, Coatesville, Pa.
†Florence Pipe Foundry & Machine Co., Florence, N. J.

We at Midvale usually feel it is more the fault of the man's supervisor, safety instructor, or his fellow workmen than the man himself.

Oftentimes the man is ordered back to work by the Works Surgeon and does not come in, especially if he belongs to some lodge or beneficial society. In such instances the man is looked up and the case thoroughly investigated to make sure that no additional complications have developed, and pressure is then brought to bear such that he obeys the doctor and returns to work.

Permit me to make myself clear as to the reactions from this lay-off procedure:

Six men are working on a job and one is injured. Why was the rest (5) sent home? Because it is evidence of dereliction of duty. They could not have been working safely 100 per cent to have permitted one of their number to have gotten hurt. By such procedure they are forcefully educated to prevent accidents. When their pay envelope is affected they will take steps to see that it does not occur again.

The man that got hurt does not feel the pain of his hurt as badly as he feels sore at heart due to having been the cause of five of his fellow men losing time—men that he works alongside of every day.

Items of Interest

George W. Stewart, Pittsburgh Representative of the Henrite Products Co., has been transferred to the New York City District of this company. Mr. C. B. Fetterolf will succeed Mr. Stewart in Pittsburgh.

Mr. E. Swift Newton, associated with the I. T. E. Circuit Breaker Co. at Philadelphia, has just returned from an extensive trip through Europe.

Howard H. Talbot, since 1923 associated with the United Engineering & Foundry Co., Pittsburgh, has been appointed chief engineer of that company, succeeding the late Lane Johnson. Mr. Talbot attended Beloit College, Beloit, Wis., and the Case School of Applied Science, Cleveland. He gained his early experience with the Connecticut Co., New Haven, Conn., a public utility subsidiary of the New York, New Haven & Hartford Railroad, and later served as engineer for the William Todd Co., Youngstown. Before going with the United Engineeriing & Foundry company, he was chief engineer for the Woodward Machine Co. department at Wooster, Ohio, of the Mackintosh-Hemphill Co., Pittsburgh.

The West Penn Power Company takes pleasure in announcing the appointment of Mr. Francis McQuillin as Industrial Sales Manager.

A group of engineers, associated with Freyn Engineering Company of Chicago, sailed April 10 bound for Russia, in fulfillment of a contract recently concluded with this company by the Soviet Government.

For the purpose of handling this work abroad, several steel mill engineers have been added to the Freyn organization. Among the new members are included the following:

Earl H. Collester, who has been associated with the Wheeling Steel Corporation in the capacity of Coke Oven Superintendent and later General Superintendent of its LaBelle Works; with the Weirton Steel Company, and with the Koppers Company in the construction of by-product coke oven plants.

L. R. Dwyer, who has been associated with the Central Alloy Steel Corporation as Open Hearth Superintendent; with the Broken Hill Proprietary Company in Australia, and with the Lackawanna Steel Company.

W. S. Orr, who was formerly Chief Engineer of the Central Alloy Steel Corporation, and with the Jones & Laughlin Steel Corporation.

Walter W. Leck, who was formerly associated with the Scullin Steel Company in the capacity of Manager of Mill Department; with the American Tube & Stamping Company as General Superintendent of Steel Works; with the Bethlehem Steel Company as Superintendent of Rolling Mills, and with the Wisconsin Steel Company.

Lee H. Mandeville, who has been associated with the Acme Steel Company as Strip Mill Superintendent; with Columbia Steel Corporation as Chief Engineer; with Wickwire, Spencer Steel Company as Electrical Engineer, and with the Pittsburgh Crucible Steel Company as Electrical Engineer.

Effective April 1, Mr. A. H. Bergendahl was appointed Manager of the Trumbull Electric Mfg. Company's New York Office upon the resignation of Mr. George Flading.

Mr. G. U. Van Cleef, who for three years has been their field specialist, will take over Mr. Bergendahl's old Cleveland-Columbus-Pittsburgh territory.

Walter G. Hoffman has resigned from his position as Assistant Superintendent of the Works Practice Department of the Jones & Laughlin Steel Corporation to become Chief Engineer of Brooke L. Jarrett & Company, Engineers, Oliver Building, Pittsburgh, Pa. Mr. Hoffman has been with Jones & Laughlin at their South Side Works for the past eight years. Prior to that time he had served as Assistant Master Mechanic and Combustion Engineer at the Saucon Plant of the Bethlehem Steel Corporation at Bethlehem, Pa.

Mr. Barton R. Shover, Consulting Engineer, has removed his office from 424 Oliver Building to 440 Oliver Building, Pittsburgh, Pa.

The Bartlett Hayward Company announce that after First their Pittsburgh Office will be located at 1947 Koppers Building, Pittsburgh, Pa.

(Continued on page 209)

A. I. & S. E. E. JUNIOR DIVISION

(Devoted to practical problems of electrical department employees in the Iron and Steel Industry)

Part II—Steel Mill Lighting

This is the second of the series of articles on mill illumination prepared by K. A. Staley, National Lamp Works of General Electric Co.

The increasing attention paid to the proper functioning of Safety Departments and to the elimination of working hazards in general has centered a great deal of attention on the value of proper illumination in steel mills. This growing scrutiny has attempted to determine what part lighting plays in reducing lost-time accidents, those involving time-loss due to spoilage, and those less serious which involve a certain unchargeable amount of paid time and medical attention.

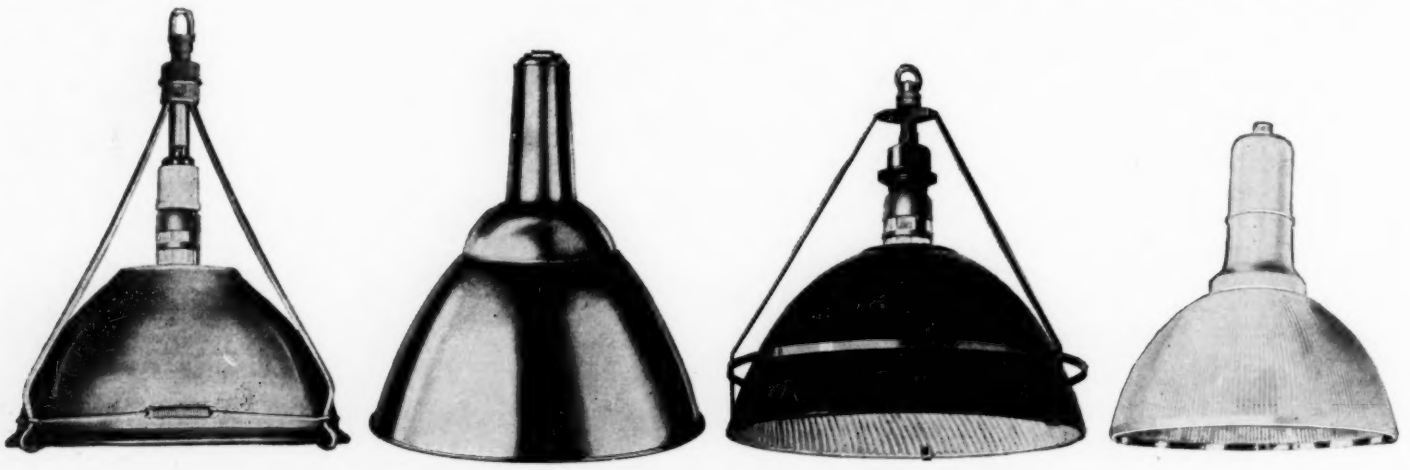


FIG. 1—A group of modern high-bay lighting units. These supersede all forms of flat shades, clusters, and renovated arc lights.

A recent survey of 10,000 accidents shows that for every dollar paid by an insurance carrier for medical charges and compensation claims to injured workers, the employer, on an average, must pay at least four dollars because of incidental or hidden costs. The facts contributing to these hidden costs have been found to be:

(a) Lost time of the injured employee.
(b) Time lost by the supervisory force in assisting the injured employee, investigating the cause of the accident, training and placing a new employee, and making reports.
(c) Time and materials of the first aid and medical staff.
(d) Damage to machines, tools, and materials.
(e) Interruption of production and its ramifying consequences.
(f) Loss of profit on injured employees, productively and on idle machines.

Mr. R. E. Simpson, Engineer for the Travelers Insurance Company, in a recent article, outlined these points and from the Company's file on steel mill accidents presents the following interesting case:

"A number of workmen were engaged in tamping the sand into the moulds or flasks, preparatory for their being used for pouring. Limitation of space compelled the workmen to stack the finished forms in tiers near the narrow gauge track running through the building. A motorman pushing a number of small flat cars ran into an upright ingot mold car. The lighter weight flat cars buckled V-shape, laterally, collided with the tier of prepared moulds, and toppled them over. One of these moulds in falling, grazed the leg of one of the workmen, causing a slight skin abrasion. This necessitated a trip to the first-aid room, but the workman lost no time other than this and there was no compensation paid. There was some damage to the track bed and the cars, while the prepared moulds were so broken up and disturbed that the entire process had to be repeated.

"In this case the lighting consisted of a faint degree of overhead illumination supplemented for the most part by local lights. A 100-watt bare Mazda lamp was suspended about seven feet above the ground at the point where the flasks were assembled and tamped. This was about fifteen feet from the track and the shadow cast by the tier of pre-

pared flasks was deep enough to hide from the motorman's view the heavy standing ingot car. Clearly, then, the lack of illumination, or, if you prefer, the prevalence of deep shadow was the primary cause of this accident.

"We have reports of many stumbling accidents in steel mills. There is likely to be a great deal of smoke, especially during pouring time, or if salamanders are used for heating the building. This condition works a hardship on any overhead lighting system, and is likely to reduce the visibility of workmen on the floor. In some buildings in steel plants there are literally thousands of pieces of wood in varying sizes in use. After a short time in service these wooden pieces partake of the color of the floor and surroundings, so that there is no contrast and accidents from stumbling are prevalent.

"While the cause is given as stumbling, we must in the final analysis show that poor housekeeping and poor visibility are materially contributing factors."

Granted that in the average mill the lighting system can be placed high enough in the air to be out of the line of vision of workmen, it becomes largely a matter of furnishing sufficient foot-candles on the floor to prevent such accident-causing stumbling. Most steel mills feel that progress in lighting is desirable and that improvement in visual conditions is a paying investment. The use of high-wattage lamps (750-watt to 1500-watt) is becoming quite general in departments which contain crane runways. Not so prevalent, however, has been the adoption of proper spacing of units to secure plenty of light, consistent with standards of today's newest mills. The amount of light that should be furnished for various classes of work is shown in the following table of foot-candles. The values are given as average levels during service, which generally means that the system must produce initial values 20 to 40 per cent above these figures.

TABLE I—FOOT-CANDLES NECESSARY

Soaking Pits and Reheating Furnaces	3
Charging and Casting Floors	6
Muck and Heavy Rolling, Shearing (rough by gauge), Pickling, Cleaning	8
Automatic Machines, Red, Light Cold Rolling, Wire Drawing, Shearing (fine by line)	12
Miscellaneous Machines, Ordinary Bench Work	12
Punches, Presses, Welding	15
Fine Bench Work	15
Tin Plate Inspection	25
Tin Plate Packing, Nailing	10
Foundry Charging Floors, Tumbling, Cleaning, Pouring, and Shaking Out	8
Rough Moulding and Core Making	10
Fine Moulding and Core Making	15
Aisles, Stairways, Passageways, Tracks	4
Chipping Floor	25
Offices—Private and General	15
Accounting Departments	20
Drafting Rooms	25
Clean Chutes	2
Coke Ovens (doors)	5

When the idea of relighting is up for discussion by the Electrical or other interested Departments, it is quite necessary to take into account such factors as spacing, mounting height, foot-candles desired, loss by dust and dirt, and the proper lamp and reflector combination to give the desired foot-candlage. Some of these factors are constants or nearly so. The wrong way to rehabilitate the lighting is to "cut down the remains" (of the old system), i.e., often antique, rusty, dirt-encrusted flat shades and to substitute new, clean, shining concentrating units, "each in the same old place." If such is done, minor improvements generally results but the system never really gets out of the class that, like Topsy, "just grew" from year to year (or decade to decade). A paternal, or other, interest in the factors mentioned above is by far the better and cheaper method.

The general lighting for most areas in mills whose ceiling beams or overhead trusses are 25 feet above the floor or higher, may consist of so-called high-bay lighting units mounted on the cross-girders or suspended from them by messenger cables. Various ways of evolving from less modern forms of systems are noticeable. Probably the most frequent results from a trial of one or two units.

TABLE II—SPACING OF OUTLETS

Ceiling Height (Or Height in the Clear) (C)	Spacing Between Outlets		Spacing Between Outside Outlets and Wall		Approximate Area per Outlet (At Usual Spacings)
	Usual (D)	Maximum (For Units at Ceiling) (D)	Aisles or Storage Next to Wall (A)	Desks, Workbenches, etc., Against Wall (B)	
(Feet)	(Feet)	Not more than*		Not more than*	(Square Feet)
8	7	7½	Usually one-half actual spacing between units	3	50–60
9	8	8		3	60–70
10	9	9		3½	70–85
11	10	10½		3½	85–100
12	10–12	12		3½–4	100–150
13	10–12	13		3½–4½	100–150
14	10–13	15		4–5	100–170
15	10–13	17		4–5	100–170
16	10–13	19		4–6	100–170
18	10–20	21		4–6	100–400
20	18–24	24		5–7	300–500
22	20–25	27		5–7	400–600
24	20–30	30		6–8	400–900
26	25–30	33		8–9	600–900
30 and up	25–30	40		8–10	600–900

* Where it is definitely known that some form of indirect lighting will be used, the maximum spacing between outlets may be increased about two feet, and the distance from the outside outlets to the wall may be increased by one foot.

The danger in just hanging up one or two such units is that spacing rules, etc., are somehow ultimately disregarded. By some magic power all the area below the units, and far distant, too, is supposed to be as well-illuminated as the point just under the trial luminaire.

TABLE III—ARCHITECTS' AND ELECTRICAL CONTRACTORS' WIRING GUIDE

Actual Floor Area per Outlet	CLASS A INSTALLATIONS (Such as Offices, Drafting Rooms, Factories, etc.)	CLASS B INSTALLATIONS (Such as Stores, School Rooms)	CLASS C INSTALLATIONS (Such as Neighborhood Stores, Storage Areas in Factories* and Basements)	CLASS D INSTALLATIONS (Such as Storage Areas in Garages and Unimportant Basements)
Square Feet	Wattage Capacity per Outlet	Wattage Capacity per Outlet	Wattage Capacity per Outlet	Wattage Capacity per Outlet
65–75	300	200	150	100
75–85	300	250	150	100
85–95	350	250	200	100
95–110	400	300	200	100
110–125	450	350	250	150
125–140	500	400	250	150
140–160	600	450	300	150
160–190	700	500	350	200
190–220	800	600	400	200
220–260	950	700	450	250
260–300	1100	800	550	300
300–340	1250	950	650	300
340–390	1450	1100	750	350
390–440	1650	1250	850	400
440–500		1400	950	450
500–560		1600	1050	500
560–630		1800	1200	550
630–710			1350	650
710–800			1500	750
800–900			1700	850

* In factories it is often desirable to convert storage areas into work places to meet immediate production needs. For this reason, it is recommended that storage areas be wired according to Class B specifications.

If the spacing of outlets and the capacity of outlets are first laid out in accordance with Table II and Table III, the adoption of a fixture and a lamp size to produce a certain foot-candle level becomes

a matter of simple calculation or brief trial of 4 to 8 units hung in a typical section or bay on that spacing. Examples of modern high-bay units are shown in Fig. 1. One of the types shown can be used with dust-tight covers such as in Fig. 2. This cover-glass consists of a cadmium-coated spring-ring holder which clamps the concave clear glass to the lip of the reflector, by means of its safety-catch. The glass is sealed tightly on its sides and edge by a felt, one-piece gasket. Other types, usually heavier, consist of double cast-aluminum hinged rings in which wire-glass is suspended.

The use of chromium-plating of reflectors is rapidly becoming more widespread as new applications for this non-tarnishing plating are found. A well-designed reflector of chromium finish is comparable in efficiency as shown by Table IV, and has the important advantages of easier maintenance and longevity.

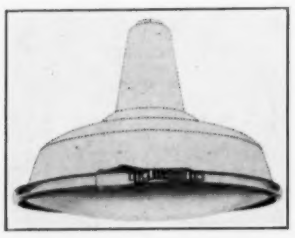
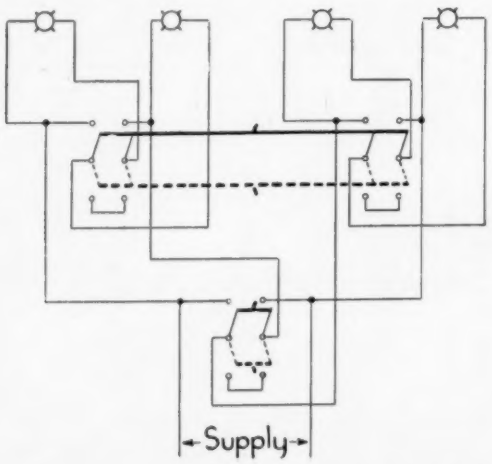


FIG. 2—New dust-tight cover for use with Standard RLM reflectors and some forms of high-bay lighting units.

TABLE IV—REFLECTION FACTORS OF MATERIALS

	% In Concentrated Beam	% Spread Beam
Mirrored Glass	82–88	
Polished Metal—		
Silver	92	
Aluminum	65	
Nickel	55	
Tin	63	
Steel	60	
Chromium	65	
Mat-Finished Metal—		
Aluminum		62
White-Oxidized Aluminum		70–75
Aluminum Paint		60–65



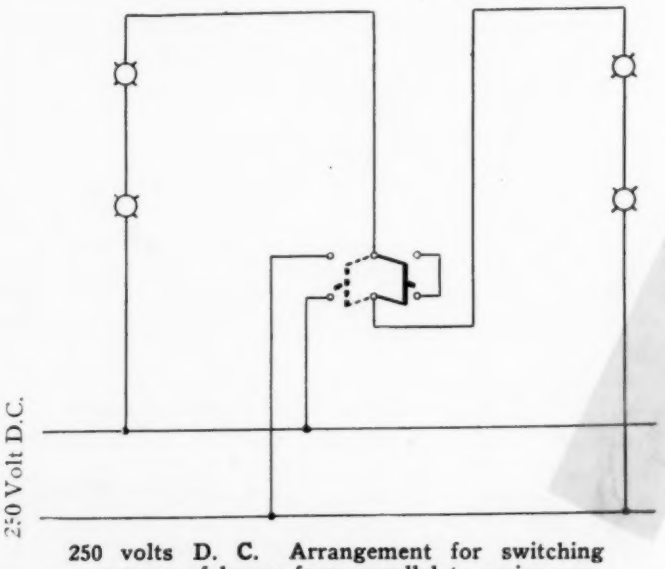
Arrangement for switching four lamps from parallel to series connection. All switches up—lamps are in parallel. All switches down—lamps are in series.

Lamp Breakage

Lamp breakage is frequently a large factor in electrical operating cost, especially in mills where lamps are subjejct to constant vibration or intermittent shock. Constant vibration is the lesser of the two evils, especially is it a less significant factor when the lamps are burned twenty-four hours a day. Filaments, when they break from vibration, usually break when cold. The lamps burn during the night, are switched off, and do not light the next night. When lamps are kept burning, the heated filaments are somewhat more "elastic" and will stand greater vibration.

This characteristic has led to the practice of rewiring such lamps on special circuits. The wiring diagram, Fig. 3, shows an arrangement for four lights on a crane. The double-pole double-throw switch is mounted in the operator's cab. During the day, or during the hours when the lighting system is not used, the lamps are switched on "series" and the filaments are accordingly kept hot, at about half-voltage. It will be noted that the 115-volt lamps are burned two in series in this hook-up. This is done in order to take advantage of the extra ruggedness of this lamp. The lamps could be changed in pairs, i.e., when one of a circuit burns out the other should be replaced at the same time.

There are a number of places, particularly in old mills, where only 250 volts d.c. is available for lighting service and when this is at a point near a loose-jointed conveyor, for example, no lamps of this voltage will stand the gaff. When a whole row of units is subjject to this sort of punishment, it is best to mount the row on a messenger cable strung from outside wall to wall. Where only one or two units are troublesome, a shock-absorber, of which there are a number available from various manufacturers, is generally a cure. Frequently, where a single socket is a lamp-wrecker, a home-made device consisting of a coiled spring and chain (the chain for a guard in case the spring breaks) will serve quite as well. Rewiring for standard spring-socket devices is not always easy to complete, it is therefore of interest here to note that one lighting equipment



250 volts D. C. Arrangement for switching groups of lamps from parallel to series connection.

FIG. 3—Wiring Schemes (115 and 250-volt sources for crane lights. The lamps are switched in series during the day.

manufacture has equipped all mogul size industrial units with double-spring shock-absorbing sockets.

For very severe cases, such as in coal-chutes, a new type of device is made which serves in the regular medium socket. This unit is called the Vibration Reducing Adapter. The Adapter is about 1 inch in length and therefore moves the lamps out from the socket an inch. For some types of enclosed equipment, such as vapor-proof and dust-proof and gas-proof globes, there may not be sufficient room for the V-R adapted when used with certain sizes of lamps, but in general the globes are long enough. The V-R Adapter has two principal advantages: The spring which absorbs the shock is as close as possible to the thing it protects—the lamp; and second, to install it necessitates no change in wiring.

One of the most rigorous services to which lamps are put, is extension cord service. For such service lamp manufacturers provide what is called the Rough Service lamp, 50-watt A-type (inside-frosted) bulb, 115-volt class only (not 230). This lamp has an extra row of supports for the filament and is far superior to any other lamp for this work. In a subsequent article, lighting layoyuts for many of the locations shown in Table I will be included together with a discussion of correct types of equipment for each.

ITEMS OF INTEREST

(Continued from page 205)

INSPECTION VS. UPKEEP

That an ounce of prevention is worth a pound of cure, has been successfully proved by an operating electrical engineer in one of our largest steel plants which contains approximately 6000 motors, ranging from 1 to 7000 horsepower.

After a visit to this plant and a careful survey of the cost sheets, it must be admitted that for this particular plant the policy of rigid inspection has been an economic success.

For example, in a six month period with the plant operating not less than 85 per cent capacity the average number of Armature Rewinds was 30 per month, the average number of Armature Changes for minor repairs were 90 per month, the average cost of Armature Coils per month being $1,008.25.

Every motor in this plant has the appearance of being freshly painted, the thought being that the inspector will contribute more to a clean job rather than a dirty greasy one. Inspectors are required to not only keep motors clean but to frequently test them.

NEW LARGE GEAR GENERATING MACHINE

A new gear generating machine has recently been built by the Farrel-Birmingham Company, Inc., Buffalo, N. Y., to generate helical, spur and herringbone gears of larger pitch than has hitherto been possible.

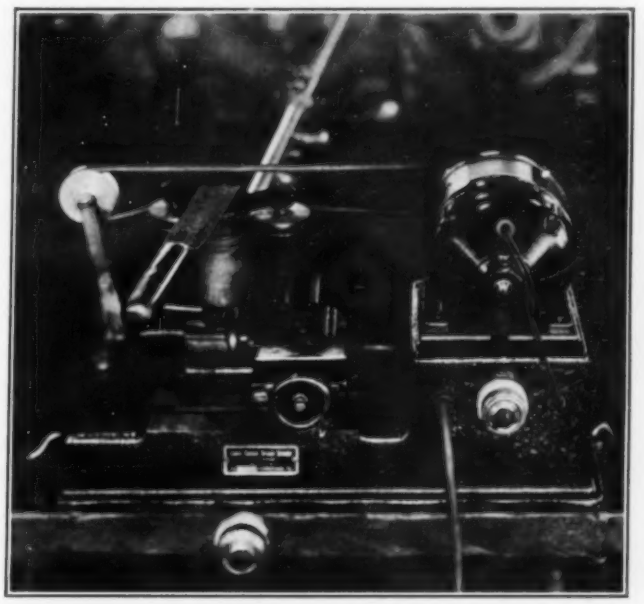
The new machine will generate gears up to 19′ diameter with a 54″ face width and will cut a continuous herringbone tooth up to .75 DP and straight tooth gears up to 6″ CP. Cutters up to 18″ pitch diameter are employed.

There is a large demand in certain branches of industry for accurately generated gears of large pitch, both herringbone and spur, and it is claimed that this new large gear generating machine will meet the most exacting requirements.

NEW BRUSH GRINDER

There has recently been placed on the market a device for grinding brushes which makes it possible to carry in stock a set of brushes ground ready for installing on motors and generators.

The machine is so designed that the arm carrying the rotating grinding wheel can be adjusted to the exact radius of the commutator and the brush clamp can be adjusted to give the desired angle of the brush to the commutator.



The operation of the machine is as follows: Set swing of grinding wheel to one-half diameter of commutator. Set brush clamp, or Turret, in line with grinding wheel. Loosen set screws in Turret and place old brush taken from machine in brush clamp, then adjust so that this same radius and angle can be produced on brush desired to grind.

This machine saves considerable time when it becomes necessary to change brushes, insures a good fit, and makes it possible to install a complete set of brushes without getting carbon dust all through the windings.

A number of installations have been made and the results are very satisfactory.

NEW LUBRICATION BULLETIN

The Morgan Engineering Company of Alliance, Ohio, have issued a Lubrication Bulletin which gives lubrication instructions covering equipment they build.

This is a twenty page bulletin and copy will be sent all interested parties upon request.

ADVERTISING PAGES REMOVED

Papers to be Presented Before the British Iron and Steel Institute—May, 1929

"The Mechanical and Metallurgical Properties of Spring Steels as Revealed by Laboratory Tests," by G. A. Hankins, D. Sc., A. R. C. S., and Miss G. W. Ford, B. Sc.

"The Erosion of Guns," by R. H. Greaves, M. B. E., D. Sc., F. I. C.; H. H. Abram, M. Sc., F. Inst. P., and S. H. Rees, B. Sc. (Research Department, Woolwich.)

"Brittleness in Mild Steel," by G. R. Bolsover, F. Inst. P. (Sheffield.)

"A Method for the Estimation of Hydrogen in Steel," by T. E. Rooney, A. M. S. T., F. I. C., and Guy Barr, B. A., D. Sc. (National Physical Laboratory.)

The A. I. B. Sinter Plant at Messrs. Guest, Keen and Nettlefolds, Ltd., Cardiff Works, by W. E. Simons (Cardiff.)

"The Influence of Pickling Operations on the Properties of Steel," by H. Sutton, M. Sc. (Farnborough, Hampshire.)

"The Microstructure of Rapidly Cooled Steel," by J. M. Robertson, B. Sc., Ph. D., A. R. T. C. (London.)

"The Oxidation of Iron and Steel at High Temperatures," by L. B. Pfeil, D. Sc., A. R. S. M. (Swansea.)

"A New Method for the Production of Sound Steel," by the Hon. Sir Charles Parsons, O. M., K. C. B., F. R. S., and H. M. Duncan, B. Sc. (Newcastle-Upon-Tyne.)

"Constitutional Diagrams for Cast Irons and Quenched Steels," by A. L. Norbury, D. Sc. (British Cast Iron Research Association, Birmingham.)

Third Report on the Heterogeneity of Steel Ingots by a Committee of the Iron and Steel Institute.

"The Differential Method for Measuring the Thickness of Hard Cases Without Sectioning Them," by Edward G. Herbert, B. Sc., M. I. Mech. E., and Paul Whitaker. (Manchester.)

"The Transformation of Austenite Into Martensite in a 0.8 Per Cent Carbon Steel," by Dartrey Lewis, M. Met. (Bridgeport, Conn.)

"Twenty Months' Results of Dry Blast Operation," by Edwin H. Lewis, M. A., F. Inst. F. (Wishaw.)

First Report on Blast Furnace Plant and Practice by Committee No. 2 of the Iron and Steel Institute.

Copies of the above papers will be furnished to the membership of the A. I. & S. E. E. at the regular price.